Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form.

1. Radiation Surveillance Network January 1965

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators telephone any daily field estimates over 10 pc/m³ to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. Lower field estimates are reported to the Center by the laboratory at Rockville, Maryland, which receives a daily written report together with the air filter submitted by each station operator. The filters are counted at the laboratory to confirm field estimates. Analyses for specific radionuclides may also be made if gross beta activity concentrations are high. All field estimates are reported elsewhere on a monthly basis (1). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90} standard. Each filter is counted 4 days after the end of the sampling period and again 7 days later if the net count rate is 3,000 cpm or higher. The initial 4-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (2), the age of fission products is estimated, and the activity extrapolated to the time of
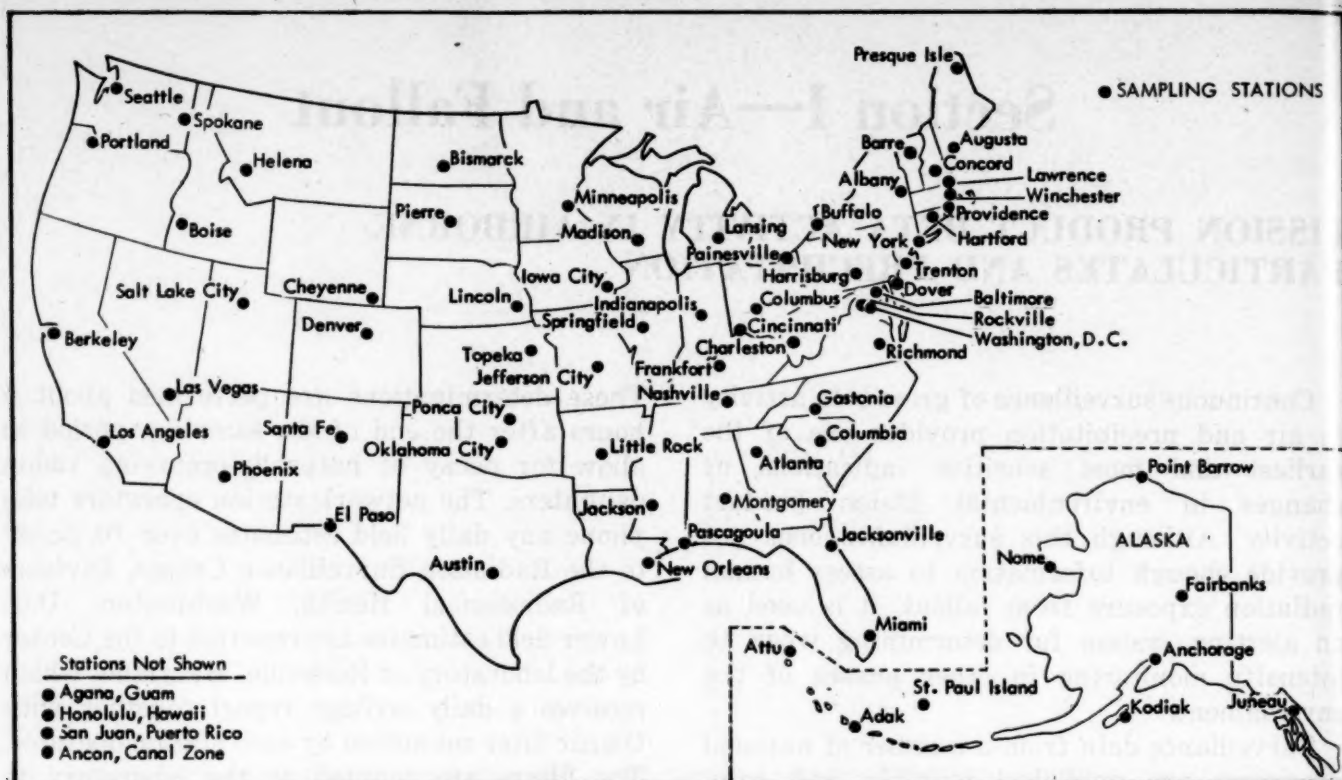
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (1).

The January 1965 air sampling results are given in table 1. Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

During January 1965, 125 air samples were analyzed by gamma spectroscopy. The method discussed by Burrus (3) and Covell (4) was adapted for resolving the complex gamma scan data. Only two air samples and no precipitation samples were found to contain identifiable short-lived radionuclides. Tellurium-iodine-132 was present in Los Angeles samples for January 13 and 14 at concentrations of approximately 1.5 pc/m^3; I^{131}, Np^{239}, Ba-La^{140}, Zr-Nb^{95}, Ru-Rh^{103,106} were identified at concentrations below 1 pc/m^3.

Precipitation measurements

Continuous sampling for radioactivity in precipitation is conducted at most stations on

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is of some intermediate value; consequently the calculated age of the fresh component will be over-estimated.

a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml portion of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by: $D = CP/1000$, where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The January 1965 precipitation measurements are given in table 1.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, JANUARY 1965

| Station location | Air surveillance | | | | | Precipitation measurements | |
| | Number of samples | Gross beta activity, pc/m³ | | | Last profile in *RHD* | Total depth (mm) | Total deposition (nc/m²)[b] |
		Maximum	Minimum	Average [a]			
Ala: Montgomery	31	0.35	<0.10	<0.22	May 65	162.7	32.5
Alaska: Adak	24	0.28	<0.10	<0.15	Nov 64	b	b
Anchorage	30	0.46	<0.10	0.22	May 65	12.2	2.4
Attu Island	17	0.29	<0.10	<0.14	Dec 64		
Fairbanks	19	0.20	<0.10	<0.13	Aug 64	7.1	1.4
Juneau	13	0.24	<0.10	<0.13	Sep 64	2.2	0.5
Kodiak	16	0.81	<0.10	<0.29	Oct 64		
Nome	14	0.25	<0.10	<0.15	Feb 65		
Point Barrow	27	0.27	<0.10	0.13	Jan 65		
St. Paul Island	28	0.44	<0.10	<0.20	Mar 65		
Ariz: Phoenix	22	1.00	0.11	0.37	Sep 64		
Ark: Little Rock	25	0.41	0.11	0.22	Sep 64	116.4	23.3
Calif: Berkeley	29	0.38	<0.10	<0.13	Oct 64	98.0	19.4
Los Angeles	27	1.81	<0.10	0.39	Feb 65	19.2	3.8
Canal Zone: Ancon	15	0.30	<0.10	<0.14	Nov 64		
Colo: Denver	23	0.50	<0.10	0.26	Oct 64	7.2	1.5
Conn: Hartford	26	0.38	<0.10	0.21	Oct 64	29.9	7.7
Del: Dover	17	0.46	0.15	0.27	May 65		
D. C.: Washington	27	0.52	<0.10	0.28	Feb 65	55.3	12.7
Fla: Jacksonville	27	0.44	<0.10	0.27	Sep 64	10.5	2.3
Miami	30	0.65	0.11	0.30	Oct 64	38.8	8.0
Ga: Atlanta	9	0.32	<0.10	0.20	Apr 65		
Guam: Agana	30	0.81	<0.10	0.34	Apr 65		
Hawaii: Honolulu	30	0.57	<0.10	0.22	Dec 64	38.4	8.4
Idaho: Boise	24	0.61	<0.10	<0.19	Dec 64	74.3	15.8
Ill: Springfield	31	0.34	<0.10	0.20	Feb 65		
Ind: Indianapolis	27	0.37	0.13	0.22	Apr 65	88.4	18.2
Iowa: Iowa City	28	0.51	<0.10	0.25	Nov 64	51.0	10.5
Kans: Topeka	25	0.38	<0.10	0.20	May 65	41.6	8.4
Ky: Frankfort	23	0.42	<0.10	0.28	Feb 65	48.0	10.7
La: New Orleans	27	0.42	<0.10	0.21	Feb 65	33.5	6.7
Maine: Augusta	30	0.40	0.12	0.26	Mar 65	45.0	9.3
Presque Isle	19	0.32	<0.10	0.20	Nov 64		
Md: Baltimore	20	0.33	<0.10	0.22	Oct 64	10.0	2.0
Rockville	15	0.42	<0.10	0.24	Jan 65		
Mass: Lawrence	31	0.51	<0.10	0.28	May 65	15.1	3.8
Winchester	28	0.64	0.20	0.36	Dec 64	64.4	65.8
Mich: Lansing	31	0.42	<0.10	0.23	Jan 65		
Minn: Minneapolis	21	0.37	<0.10	0.16	Apr 65	7.0	1.7
Miss: Jackson	28	0.58	<0.10	0.23	Mar 65	69.7	13.9
Pascagoula	12	0.40	<0.10	0.27	Dec 64		
Mo: Jefferson City	29	0.31	<0.10	0.18	Apr 65	87.0	19.2
Mont: Helena	30	0.54	<0.10	<0.19	Nov 64	6.39	1.40
Nebr: Lincoln	14	0.60	<0.10	0.26	Mar 65		
Nev: Las Vegas	28	0.69	<0.10	0.27	Aug 65		
N. H: Concord	20	0.52	0.17	0.33	Feb 65		
N. J: Trenton	31	0.53	<0.10	0.26	Mar 65	14.8	3.2
N. Mex: Santa Fe	27	0.56	<0.10	0.23	Nov 64	30.9	6.1
N. Y: Albany	21	0.68	0.14	0.26	Apr 64	34.5	6.9
Buffalo	23	0.55	0.16	0.28	Nov 64		
New York	22	0.56	0.16	0.30	Dec 64		
N. C: Gastonia	27	0.63	<0.10	0.31	Nov 64	54.4	10.9
N. Dak: Bismarck	28	0.32	<0.10	0.17	Jan 65	18.6	3.7
Ohio: Cincinnati	21	0.37	0.11	0.20	May 65		
Columbus	29	0.75	<0.10	0.33	Mar 65	51.5	12.7
Painesville	30	0.60	<0.10	0.33	Oct 64	96.8	22.1
Okla: Oklahoma City	28	0.41	<0.10	0.18	Jan 65		
Ponca City	28	0.28	<0.10	<0.13	Oct 64	47.6	9.9
Ore: Portland	27	0.69	<0.10	<0.21	Mar 65	122.0	28.4
Pa: Harrisburg	29	0.49	<0.10	0.22	Apr 65	29.4	5.9
P. R: San Juan	29	0.49	<0.10	<0.18	Mar 65	36.2	7.2
R. I: Providence	27	0.52	0.12	0.27	Jan 65	11.4	2.6
S. C: Columbia	27	0.72	<0.10	0.26	Dec 64	38.6	10.0
S. Dak: Pierre	31	0.33	0.13	0.19	Sep 64		
Tenn: Nashville	29	0.58	<0.10	0.28	Jan 65	73.4	16.0
Tex: Austin	28	0.46	0.11	0.28	May 65	73.6	14.9
El Paso	27	1.37	<0.10	0.46	Jan 65	5.6	1.5
Utah: Salt Lake City	27	0.84	<0.10	0.28	Feb 65	56.5	11.8
Vt: Barre	29	0.65	0.19	0.34	Sep 64	18.0	5.6
Va: Richmond	31	0.34	<0.10	0.20	Sep 64	39.1	8.5
Wash: Seattle	30	0.26	<0.10	<0.12	May 65	102.8	20.6
Spokane	31	0.40	<0.10	<0.16	Apr 65		
W. Va: Charleston	30	0.57	<0.10	0.29	Dec 64	89.4	18.5
Wis: Madison	30	0.64	<0.10	0.27	Sep 64	19.5	3.9
Wyo: Cheyenne	30	1.04	<0.10	0.35	Aug 64	6.5	2.3
Network summary [c]	1,904	1.81	<0.10	<0.24		46.2	10.9

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.
[b] Blank indicates no report received.
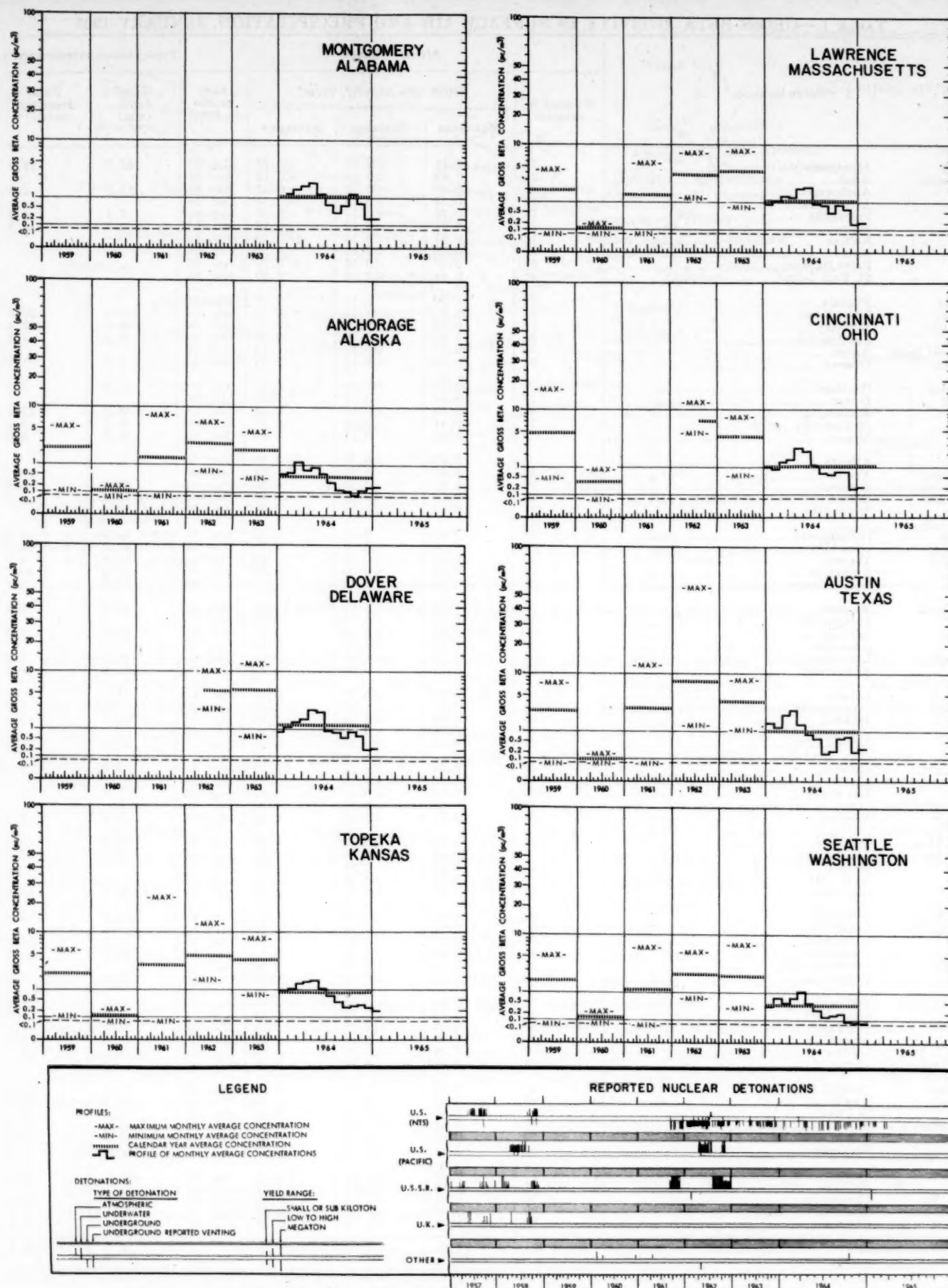[c] For the network summary, all averages are arithmetic means of station averages.

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—
RADIATION SURVEILLANCE NETWORK, 1959—JANUARY 1965

2. Canadian Air Monitoring Program[2]
January 1965

*Department of National
Health and Welfare*

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (5–9).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end window, gas-flow, Geiger-Mueller

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[2] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Programs*, Vol. 3, No. 2: 16–24 (February 1965), Canadian Department of National Health and Welfare, Ottawa, Canada.

counter system calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for January 1965 are given in table 2.

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450 degrees C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for January 1965 samples are given in table 2. Radionuclide analyses are reported quarterly in *RHD*.
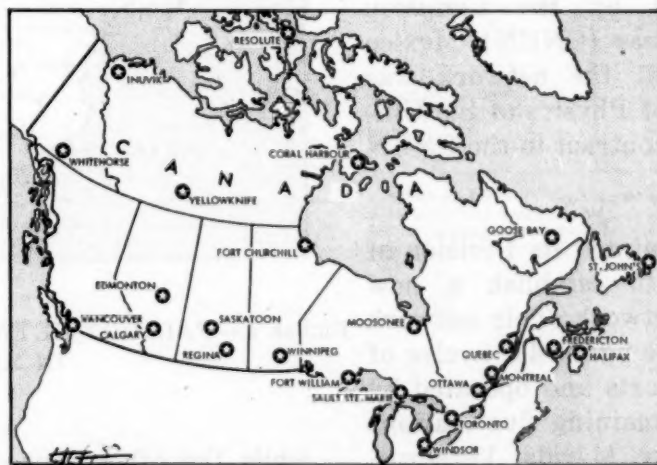

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	31	0.3	0.0	0.2	207	1.9
Coral Harbour	31	0.3	0.0	0.2	241	2.4
Edmonton	31	0.2	0.0	0.2	52	2.6
Ft. Churchill	31	0.3	0.0	0.2	86	1.5
Ft. William	29	0.5	0.0	0.3	90	1.9
Fredericton	31	0.2	0.0	0.1	55	3.4
Goose Bay	31	0.3	0.1	0.2	410	3.4
Halifax	31	0.3	0.1	0.2	131	13.5
Inuvik	31	0.4	0.1	0.2	66	1.1
Montreal	31	0.4	0.1	0.3	92	5.1
Moosonee	31	0.3	0.1	0.2	41	2.1
Ottawa	30	0.5	0.1	0.2	50	2.7
Quebec	31	0.3	0.2	0.2	65	6.2
Regina	31	0.6	0.0	0.2	106	0.9
Resolute	31	0.3	0.0	0.2	trace	2.5
St. John's, Nfld.	29	0.3	0.0	0.1	35	4.2
Saskatoon	15	0.3	0.0	0.2	122	1.1
Sault Ste. Marie	31	0.4	0.0	0.2	38	4.2
Toronto	31	0.3	0.0	0.2	105	9.8
Vancouver	31	0.2	0.0	0.1	56	10.7
Whitehorse	31	0.0	0.0	0.2	62	1.0
Windsor	31	0.4	0.0	0.2	83	9.6
Winnipeg	31	0.4	0.1	0.2	305	1.7
Yellowknife	31	0.3	0.1	0.2	121	0.9
Network summary	704	0.3	0.0	0.2	114	3.9

3. Mexican Air Monitoring Program January 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (10–14).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the station at Mexico City,

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the

University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during January 1965 are presented in table 3.

TABLE 3.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, JANUARY 1965

Station	Number of samples	Gross beta activity, pc/m³		
		Maximum	Minimum	Average
Acapulco	8	0.2	<0.1	0.1
Ciudad Juárez	18	0.5	<0.1	0.2
Chihuahua	12	0.4	<0.1	0.2
Ensenada	11	0.3	<0.1	0.2
Guadalajara	9	0.2	<0.1	0.1
Guaymas	11	0.4	<0.1	0.1
La Paz	18	0.6	0.1	0.3
Matamoros	6	(a)	(a)	<0.1
Mazatlán	—	—	—	—
Mérida	10	0.3	<0.1	0.1
México, D.F.	12	0.1	<0.1	<0.1
Nuevo Laredo	10	(a)	(a)	<0.1
San Luis Potosí	12	0.2	<0.1	0.1
Tampico	13	0.9	0.1	0.2
Torréon	13	0.5	<0.1	0.2
Tuxtla Gutiérrez	(a)	(a)	(a)	(a)
Veracruz	5	0.3	<0.1	0.1

a Station temporarily shut down.

4. Pan American Air Sampling Program January 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The five air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupatonal Health; in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964, and the other three were started near the end of 1962.

The January 1965 air monitoring results from the four participating countries are given in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN AIR, JANUARY 1965

Sampling stations	Gross beta activity, pc/m³			
	No. of samples	Maximum	Minimum	Average a
Kingston, Jamaica	18	0.32	<0.10	<0.14
Caracas, Venezuela	20	0.19	<0.10	<0.10
Lima, Peru	0			
Santiago, Chile	28	0.31	<0.10	<0.14

a The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

5. Gross Beta Activity in Air, North America January 1965

Beginnning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (15).

With the formation of the Mexican Air Monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (16). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

During January 1965, gross beta activity was less than 0.5 pc/m³ at all stations; therefore, an isogram is not presented.

REFERENCES

(1) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. Division of Radiological Health, Public Health Service, Washington, D.C. 20201 (distribution by official request).
(2) WAY, K. and E. P. WIGNER. The rate of decay of fission products. Phys Rev 73: 1318–30 (June 1, 1948).
(3) BURRUS, W. R. Unscrambling scintillation spectrometer data. IRE Trans. Nucl. Sc. NS–7, 2–3: 102–111 (1960).
(4) COVELL, D. F. Determination of gamma ray abundance directly from total absorption peak. Anal Chem 31:1785–1790 (November 1959).
(5) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program. CNHW–RP–3, Department of National Health and Welfare, Ottawa, Canada (May 1960).
(6) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program. CNHW–RP–4, Department of National Health and Welfare, Ottawa, Canada (December 1961).
(7) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program. CNHW–RP–5, Department of National Health and Welfare, Ottawa, Canada (December 1962).
(8) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program. RPD–11, Department of National Health and Welfare, Ottawa, Canada (July 1962).
(9) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada. RPD–21, Department of National Health and Welfare, Ottawa, Canada (August 1962).
(10) ALBA, F., V. BELTRAN, T. A. BRODY, H. LEZAMA, A. MORELO, A. TEJERA, and M. VASQUEZ. Primer Informe sobre Estudios de la Lluvia Radiactiva. Revista Mexicana de Física 5: 153–166 (1956).
(11) ALBA, F., T. A. BRODY, H. LEZAMA, A. TEJERA, and M. VASQUEZ. Segundo Informe sobre Precipitación Radiactiva. Revista Mexicana de Física 6: 97–104 (1957).
(12) ALBA, F., T. A. BRODY, R. CAMERAS, A. PALACIOS, G. RICHARDS, A. TEJERA, and E. G. B. DEVELARDE. Tercer Informe sobre Precipitación Radiactiva. Publicación de la Comisión Nacional de Energía Nuclear (1958).
(13) ALBA, F., T. BRODY, and A. PALACIOS. Cuarto Informe sobre Estudios de la Precipitación Radiactiva. Revista Mexicana de Física 8: 60–85 (1965).
(14) BRODY, T. A., S. BULBULIAN, J. CALVILLO, and A. M. MARTINEZ. Quinto Informe sobre Estudios de Precipitación Radiactiva. Revista Mexicana de Física 8: (1961).
(15) LOCKHART, L. B., JR. and R. L. PATTERSON, JR. Intercalibration of some systems employed in monitoring fission products in the atmosphere. NRL Report 5850, Naval Research Laboratory, Washington, D.C. 20390 (November 13, 1962); abstracted in RHD, December 1962.
(16) LOCKHART, L. B., JR. and R. L. PATTERSON, JR. Intercalibration of the major North American networks employed in monitoring airborne fission products. NRL Report 6025, Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in RHD, January 1964.

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network
January 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

Analytical procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (E D T A) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for the preceding quarter and January 1965 (actual reporting period is December 27, 1964 —January 30, 1965). The radionuclide values

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.
[2] The conversion factor is 1.18 x 10⁻³ g K/pc K⁴⁰.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	± 5	50 or greater	±10
Strontium-90	0 to 20	± 2	20 or greater	±10

[a] Two standard deviations (2σ).

reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In tables 3 and 4, the distribution of the network's stations *versus* radionuclide concentrations in milk for the last 6 months are compared.

The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

For special purposes of comparison and reference, the Network maximum, minimum, and average monthly radionuclide concentrations for the early years of operation (March 1960—March 1964) were summarized in tabular form in the July 1964 *RHD* (*2*). An annual summary for 1964 appeared in the April 1965 *RHD* (*3*).

TABLE 2.—AVERAGE CONCENTRATION OF STABLE ELEMENTS AND RADIONUCLIDES [a] IN PASTEURIZED MILK, FOURTH QUARTER 1964 AND JANUARY 1965

Sampling locations		Calcium (g/liter)		Strontium-89 (pc/liter)		Strontium-90 (pc/liter)		Cesium-137 (pc/liter)		Iodine-131 (pc/liter)	
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month
Ala:	Montgomery	1.20	1.18	<5	<5	19	20	60	55	0	0
Alaska:	Palmer	1.22	1.14	<5	<5	19	15	80	65	0	0
Ariz:	Phoenix	1.19	1.17	<5	<5	4	3	25	25	0	0
Ark:	Little Rock	1.17	1.18	<5	<5	33	33	60	70	0	0
Calif:	Sacramento	1.26	1.23	<5	<5	5	5	25	35	0	0
	San Francisco	1.22	1.21	<5	<5	8	8	30	35	0	0
C. Z:	Cristobal	1.14	1.16	<5	<5	5	6	50	45	0	0
Colo:	Denver	1.29	1.29	<5	<5	16	17	65	55	0	0
Conn:	Hartford	1.13	1.10	<5	<5	14	16	85	90	0	0
Del:	Wilmington	1.17	1.15	<5	<5	16	18	70	80	0	0
D. C:	Washington	1.15	1.15	<5	<5	17	19	45	55	0	0
Fla:	Tampa	1.18	1.18	<5	<5	15	13	210	175	0	0
Ga:	Atlanta	1.20	1.21	<5	<5	24	26	85	85	0	0
Hawaii:	Honolulu	1.20	1.15	5	<5	13	11	70	70	0	0
Idaho:	Idaho Falls	1.23	1.22	<5	<5	19	18	80	110	0	0
Ill:	Chicago	1.16	1.12	<5	<5	16	16	75	85	0	0
Ind:	Indianapolis	1.20	1.20	<5	<5	15	16	60	70	0	0
Iowa:	Des Moines	1.22	1.13	<5	<5	21	21	55	50	0	0
Kans:	Wichita	1.26	1.27	<5	<5	17	16	40	45	0	0
Ky:	Louisville	1.18	1.18	<5	5	23	23	45	60	0	0
La:	New Orleans	1.23	1.23	10	<5	40	40	75	75	0	0
Maine:	Portland	1.18	1.14	<5	<5	24	22	145	140	0	0
Md:	Baltimore	1.16	1.18	<5	<5	18	17	50	60	0	0
Mass:	Boston	1.15	1.13	<5	<5	22	22	125	140	0	0
Mich:	Detroit	1.17	1.13	<5	<5	15	15	75	85	10	0
	Grand Rapids	1.20	1.17	<5	<5	19	17	85	90	0	0
Minn:	Minneapolis	1.24	1.19	5	<5	24	23	80	85	0	0
Miss:	Jackson	1.23	1.26	<5	<5	32	33	60	55	0	0
Mo:	Kansas City	1.22	1.21	<5	<5	21	22	40	55	0	0
	St. Louis	1.24	1.23	<5	<5	18	16	45	50	0	0
Mont:	Helena	1.25	1.19	<5	<5	16	17	85	90	0	0
Nebr:	Omaha	1.19	1.29	<5	<5	17	15	45	45	0	0
Nev:	Las Vegas	1.24	1.29	<5	<5	8	8	50	40	0	0
N. H:	Manchester	1.18	1.17	<5	<5	23	24	155	165	0	0
N. J:	Trenton	1.12	1.12	<5	<5	15	14	70	80	0	0
N. Mex:	Albuquerque	1.23	1.21	<5	<5	9	12	45	45	0	0
N. Y:	Buffalo	1.11	1.12	<5	<5	16	16	90	105	0	0
	New York	1.15	1.11	<5	<5	19	16	95	105	0	0
	Syracuse	1.12	1.09	<5	<5	15	16	90	95	0	0
N. C:	Charlotte	1.21	1.22	<5	<5	33	30	65	65	0	0
N. Dak:	Minot	1.19	1.18	<5	<5	38	54	110	130	0	0
Ohio:	Cincinnati	1.19	1.17	<5	<5	17	17	60	70	0	0
	Cleveland	1.17	1.16	<5	<5	18	17	75	90	0	0
Okla:	Oklahoma City	1.18	1.19	5	5	18	15	45	50	0	0
Ore:	Portland	1.29	1.29	<5	<5	22	15	90	80	0	0
Pa:	Philadelphia	1.18	1.15	<5	<5	16	16	65	70	0	0
	Pittsburgh	1.18	1.15	<5	<5	24	24	85	105	0	0
P. R:	San Juan	1.14	1.15	<5	<5	10	12	50	55	0	0
R. I:	Providence	1.17	1.16	<5	<5	18	20	95	105	0	0
S. C:	Charleston	1.17	1.19	<5	<5	29	28	90	85	0	0
S. Dak:	Rapid City	1.03	1.08	<5	<5	27	27	115	125	0	0
Tenn:	Chattanooga	1.20	1.24	5	<5	31	32	65	70	0	0
	Memphis	1.20	1.19	<5	<5	25	26	45	45	0	0
Tex:	Austin	1.14	1.15	<5	<5	7	8	25	30	0	0
	Dallas	1.18	1.18	<5	<5	15	19	35	45	0	0
Utah:	Salt Lake City	1.34	1.27	<5	<5	18	21	90	125	0	0
Vt:	Burlington	1.16	1.10	<5	<5	20	21	105	120	10	0
Va:	Norfolk	1.19	1.18	<5	<5	21	23	60	60	0	0
Wash:	Seattle	1.24	1.24	<5	<5	20	21	95	85	0	0
	Spokane	1.30	1.28	<5	<5	22	23	95	110	0	0
W. Va:	Charleston	1.16	1.17	<5	<5	17	15	40	50	0	0
Wis:	Milwaukee	1.22	1.18	<5	<5	14	14	85	95	0	0
Wyo:	Laramie	1.22	1.31	<5	<5	15	13	70	65	0	0
Network average		1.19	1.18	<5	<5	19	19	73	78	0	0

[a] Barium-140 analyses were also conducted but all results were zero.

STRONTIUM-90(pc/liter)

Stations Not Shown
Palmer, Alaska _____ 15
Honolulu, Hawaii _____ 11
San Juan, Puerto Rico ___ 12
Cristobal, Canal Zone ___ 6
● Sampling Stations
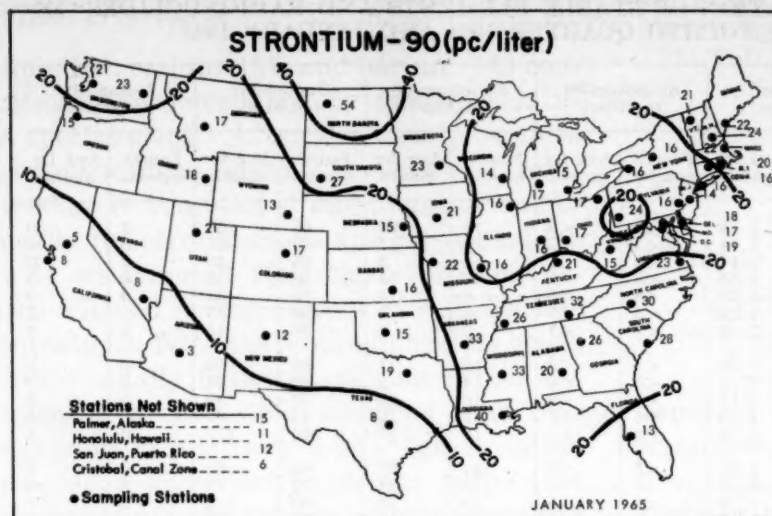
JANUARY 1965

FIGURE 1.—STRONTIUM–90 CONCENTRATIONS IN
PASTEURIZED MILK, JANUARY 1965

CESIUM–137(pc/liter)

Stations Not Shown
Palmer, Alaska _____ 65
Honolulu, Hawaii _____ 70
San Juan, Puerto Rico ___ 55
Cristobal, Canal Zone ___ 45
● Sampling Stations
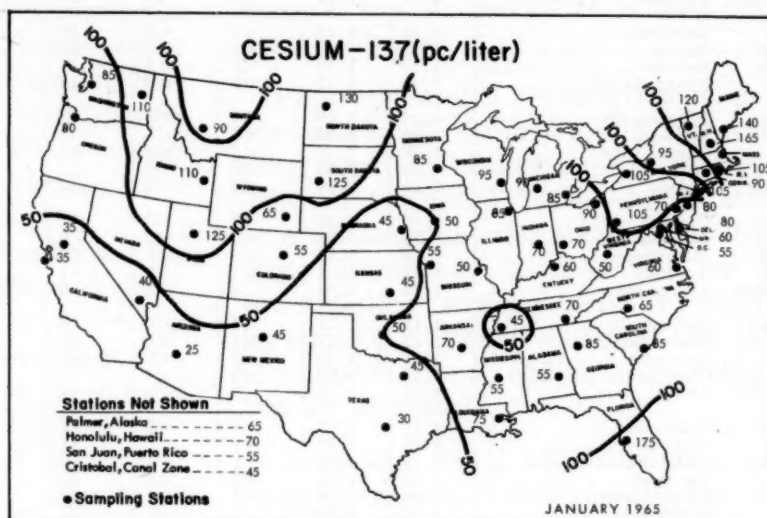
JANUARY 1965

FIGURE 2.—CESIUM–137 CONCENTRATIONS IN
PASTEURIZED MILK, JANUARY 1965

TABLE 3.—RANGES OF STATION MONTHLY AVER-
AGES FOR STRONTIUM-90, AUGUST–DECEMBER
1964; JANUARY 1965 AND JANUARY 1964

Strontium-90 range (pc/liter)	Number of stations in range						
	1964					1965	1964
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Jan.
Under 10	7	8	6	6	8	6	4
10–19	23	27	37	31	29	32	10
20–29	23	20	13	19	20	19	32
30–39	6	6	7	6	4	4	13
40–49	4	2	0	1	2	1	3
50–59	0	0	0	0	0	1	0
60–69	0	0	0	0	0	0	1
70–79	0	0	0	0	0	0	0

TABLE 4.—RANGES OF STATION MONTHLY AVER-
AGES FOR CESIUM-137, AUGUST–DECEMBER 1964;
JANUARY 1965 AND JANUARY 1964

Cesium-137 range (pc/liter)	Number of stations in range						
	1964					1965	1964
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Jan.
Under 50	6	14	16	15	9	11	2
50–99	30	33	40	41	38	38	13
100–149	19	13	6	4	14	12	25
150–199	6	2	0	2	2	2	16
200–249	1	1	1	1	0	0	5
250–349	1	0	0	0	0	0	2
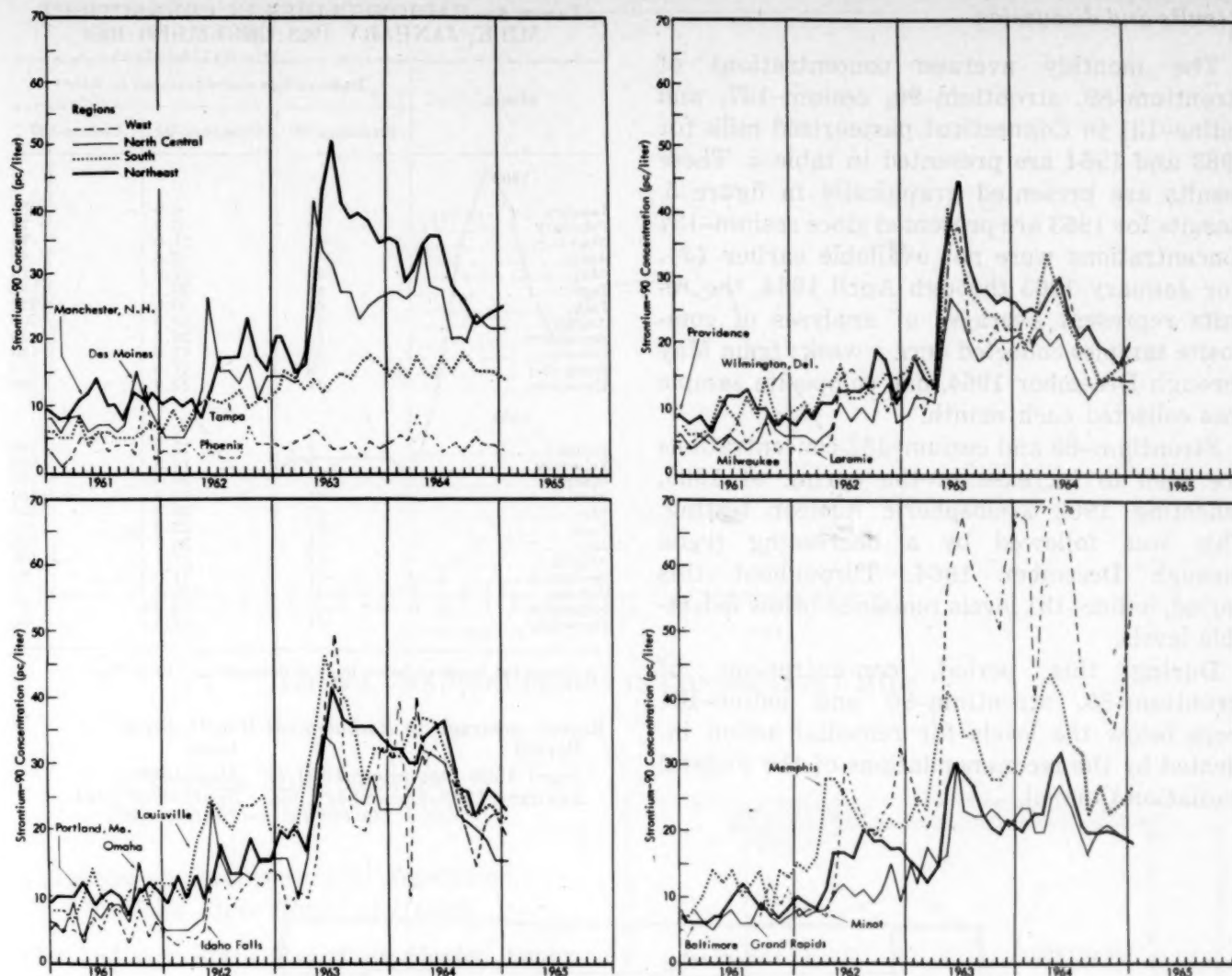
FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961—JANUARY 1965

2. Connecticut Milk Network
January—December 1964

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962 the Connecticut Milk Network program was expanded to include the determination of gamma emitting radionuclides in milk.

The sampling program is flexible in nature. Under this program, up to five areas of the State (figure 4) have been sampled at a frequency up to twice a week. Presently, a monthly sample representative of milk sold in the central area of the State is collected and analyzed for strontium–89, strontium–90, and gamma emitters. Concentrations of iodine–131 are followed as an indication of the presence of radioactivity of recent origin.

Analytical procedures

Strontium–89 and strontium–90 are determined by chemical separation and subsequent counting in a low-background Geiger-Mueller counter utilizing a thin-window, gas-flow counting chamber. Iodine–131 and other gamma emitters are determined by gamma scintillation spectroscopy. The counting system consists of a 400-channel pulse height analyzer and a 4 x 4-inch sodium iodide (thallium activated) crystal detector.

Results and discussion

The monthly average concentrations of strontium–89, strontium–90, cesium–137, and iodine–131 in Connecticut pasteurized milk for 1963 and 1964 are presented in table 5. These results are presented graphically in figure 5. Results for 1963 are presented since cesium–137 concentrations were not available earlier (3). For January 1963 through April 1964, the results represent averages of analyses of composite samples collected once a week; from May through December 1964, one composite sample was collected each month.

Strontium–89 and cesium–137 concentrations are seen to increase in the spring of 1963, reflecting 1962 atmospheric nuclear testing. This was followed by a decreasing trend through December 1964. Throughout this period, iodine–131 levels remained below detectable levels.

During this period, concentrations of strontium–89, strontium–90 and iodine–131 were below the levels for remedial action indicated by the recommendations of the Federal Radiation Council.

TABLE 5.—RADIONUCLIDES IN CONNECTICUT MILK, JANUARY 1963–DECEMBER 1964

Month	Radionuclide concentrations, pc/liter [*]		
	Strontium-89	Strontium-90	Cesium-137
1963			
January	1	8.9	70
February	2	8.9	70
March	<1	11.0	70
April	1	8.8	60
May	27	12.6	110
June	48	20.1	180
July	67	30.0	220
August	47	28.9	200
September	13	26.6	150
October	15	17.9	130
November	8	21.3	150
December	<1	22.9	160
1964			
January	2.7	18.2	160
February	7.7	19.8	160
March	<1	20.5	160
April	<1	19.9	150
May	<1	18.8	160
June	<1	22.5	120
July	<1	20.4	120
August	<1	17.1	100
September	<1	11.5	80
October	<1	13.8	70
November	<1	14.0	70
December	<1	12.3	80

[*] Iodine-131 levels all below limit of detectability, 10 pc/liter.

Recent coverage in *Radiological Health Data:*

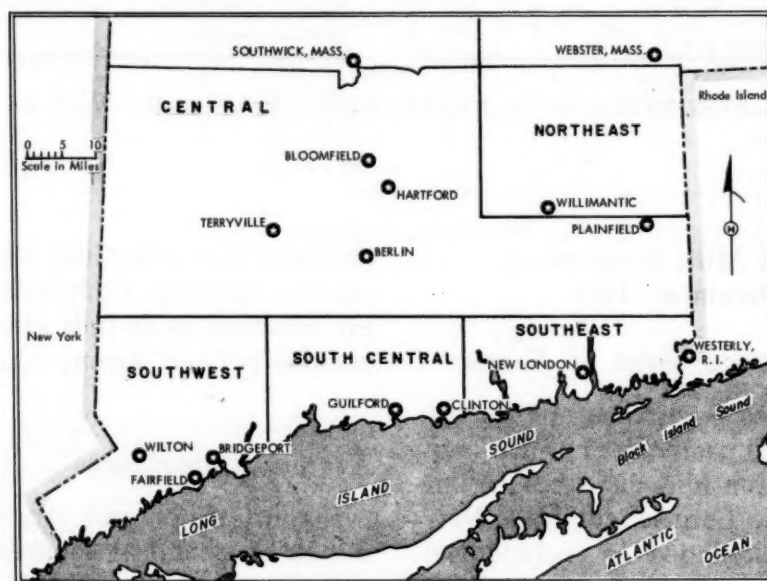| Period	Issue
April 1960–December 1962	*May 1963*
January 1963–December 1963	*September 1964*

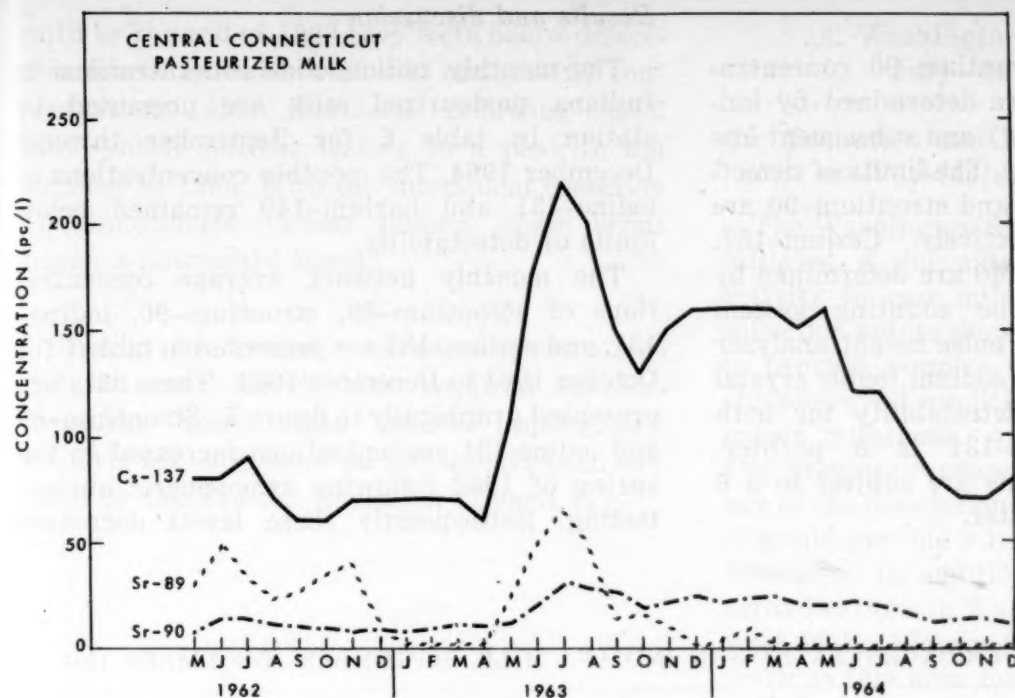FIGURE 4.—CONNECTICUT MILK SAMPLING STATIONS

FIGURE 5.—RADIONUCLIDES IN CONNECTICUT MILK

3. Indiana Milk Network
September—December 1964

Bureau of Environmental Sanitation, Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. To analyze radionuclide concentrations in Indiana milk effectively, the State was geographically divided into 5 major milksheds: Northeast, Northwest, Central, Southeast, and Southwest (figure 6). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are routinely analyzed for strontium–89, strontium–90, cesium–137, iodine–131, and barium–140. Initially, cesium–137, iodine–131, and barium–140 were analyzed weekly. When iodine–131 concentrations exceeded 100 pc/liter, the sampling frequency was increased. Since August 1963, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was reduced to once per month for the Northeast, Southeast, and Southwest milksheds. Monthly analyses for strontium–89 and strontium–90 are performed at each station.
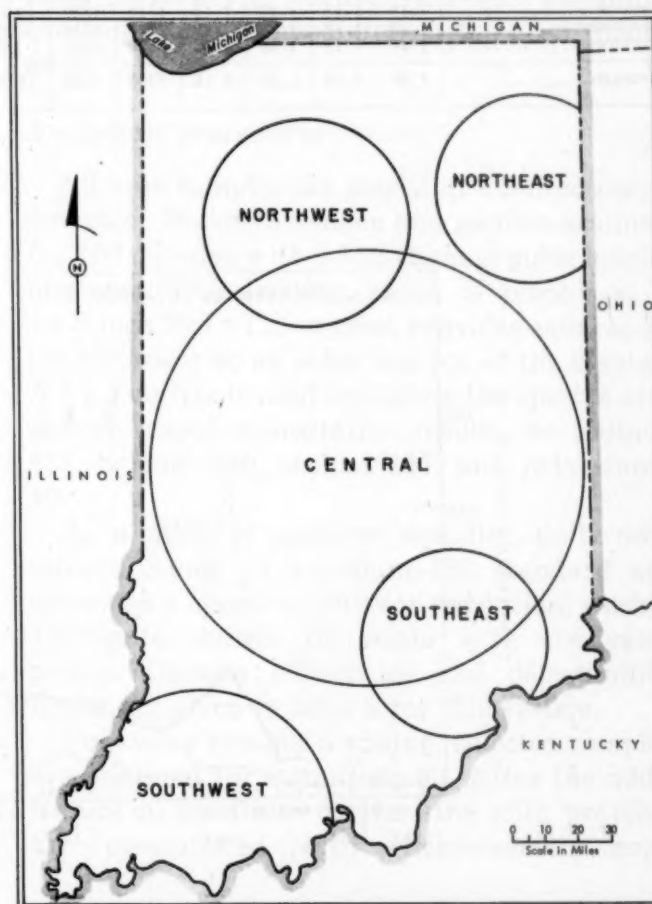
FIGURE 6.—INDIANA MILK SAMPLING LOCATIONS

Analytical procedures

Strontium–89 and strontium–90 concentrations in milk samples are determined by ion-exchange separation (5, 6) and subsequent low background beta counting. The limits of detectability for strontium–89 and strontium–90 are 5 and 1 pc/liter, respectively. Cesium–137, iodine–131, and barium–140 are determined by gamma spectroscopy. The counting system consists of a 512-channel pulse height analyzer and a shielded 4 x 4-inch sodium iodide crystal detector. The limit of detectability for both barium–140 and iodine–131 is 5 pc/liter. Cesium–137 concentrations are subject to a 6 percent error at 100 pc/liter.

Results and discussion

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 6 for September through December 1964. The monthly concentrations of iodine–131 and barium–140 remained below limits of detectability.

The monthly network average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 are presented in table 7 for October 1961 to December 1964. These data are presented graphically in figure 7. Strontium–89 and iodine–131 concentrations increased in the spring of 1962 following atmospheric nuclear testing. Subsequently these levels decreased

TABLE 6.—RADIONUCLIDE CONCENTRATIONS IN INDIANA MILK, SEPTEMBER—DECEMBER 1964

| Sampling location	Calcium, g/liter				Potassium-40, pc/liter				Strontium-89, pc/liter				Strontium-90, pc/liter				Cesium-137, pc/liter			
	Sept	Oct	Nov	Dec	Sept	Oct	Nov	Dec	Sept	Oct	Nov	Dec	Sept	Oct	Nov	Dec	Sept	Oct	Nov	Dec
Northeast	1.24	1.21	1.20	1.16	1290	1300	1290	1310	0	0	0	15	12	18	16	12	55	75	65	65
Southeast	1.18	1.18	1.26	1.16	1270	1340	1340	1340	0	0	0	0	13	15	14	22	50	55	55	70
Central	1.18	1.18	1.26	1.16	1310	1330	1330	1370	0	0	0	0	14	11	12	14	50	55	55	65
Southwest	1.20	1.18	1.26	1.16	1250	1350	1290	1410	0	0	0	0	17	17	17	18	40	50	50	70
Northwest	1.22	1.18	1.26	1.16	1320	1320	1290	1380	0	0	0	0	15	13	14	14	60	60	65	75
Average	1.20	1.19	1.25	1.16	1290	1330	1310	1360	0	0	0	5	14	15	15	16	50	60	60	70
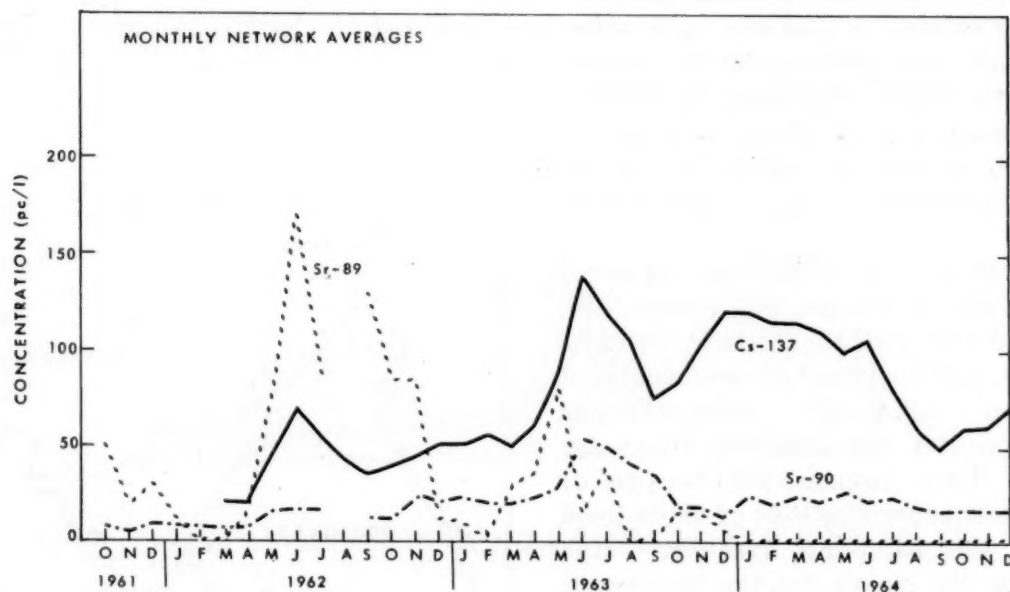
FIGURE 7.—RADIONUCLIDE CONCENTRATIONS IN INDIANA PASTEURIZED MILK NETWORK

until by the end of 1963 they were below detectable levels. Strontium–90 and cesium–137 concentrations also increased following 1962 atmospheric nuclear testing to a peak in the summer of 1963. With the subsequent cessation of atmospheric nuclear testing, these levels began a downward trend.

During the period covered, concentrations did not reach levels that required countermeasures based upon health implications. Criteria for such remedial action have been outlined by the Federal Radiation Council (7).

TABLE 7.—MONTHLY AVERAGE RADIONUCLIDE CONCENTRATIONS IN INDIANA MILK, OCTOBER 1961–DECEMBER 1964

Month and year	Radionuclide concentrations, pc/liter			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
1961				
October	50	7		
November	20	3		
December	30	8		
1962				
January	10	7		
February	a ND	7		
March	ND	6	ND	20
April	15	7	ND	20
May	75	16	30	45
June	170	16	40	70
July	90	16	20	55
August	b NA	NA	20	40
September	130	12	100	35
October	85	11	60	40
November	85	23	80	45
December	25	20	20	50
1963				
January	10	21	ND	50
February	ND	17	ND	55
March	30	18	ND	50
April	35	23	ND	60
May	80	30	ND	90
June	15	54	ND	140
July	40	49	ND	120
August	ND	41	ND	105
September	ND	36	ND	75
October	15	18	ND	85
November	10	18	ND	105
December	5	14	ND	120
1964				
January	ND	25	ND	120
February	ND	16	ND	115
March	ND	23	ND	115
April	ND	17	ND	110
May	ND	26	ND	100
June	ND	21	ND	105
July	ND	23	ND	80
August	ND	17	ND	60
September	ND	14	ND	50
October	ND	15	ND	60
November	ND	15	ND	60
December	5	16	ND	70

a ND means not detectable.
b NA indicates no analysis.

4. Washington Milk Network,[3] July—December 1964

Air Sanitation and Radiation Control Section State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 8 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. As this sampling program also provides representation of a large percentage of the population's milk supply in the State, it would provide a basis for initiating countermeasures. In addition to sampling milk from eight locations in Washington, milk from northwest Idaho (Sandpoint) is included in the network as this area forms a part of the Spokane milkshed. Several additional points are sampled from time to time.

Raw milk samples are normally collected monthly from individual tankers, but the sampling frequency is flexible. Increased sampling can be initiated immediately if the need should arise.

Analytical procedures

All milk samples are placed in a 2-liter stainless steel Marinelli beaker and gamma-scanned for 100 minutes with a 512-channel pulse height analyzer. This beaker, which is placed on a 3 x 3-inch NaI (T1) crystal, provides equal sample thickness on all sides and top of the crystal. A 4 x 4 matrix is used to analyze the spectra and provide rapid quantitative results for iodine–131, barium–140, cesium–137, and potassium–40.

As a check of analyzer stability, daily one-minute counts of a cesium–137 standard are made. As a check on detector resolution, weekly 10-minute counts are made with the same source. Gamma efficiencies and detectability limits are given in table 8 for this system.

Following gamma scanning, selected samples are analyzed for strontium–90. After the addition of a strontium carrier, the milk proteins are precipitated with trichloroacetic acid.

[3] Data from *Environmental Radiation Surveillance in Washington State*, Third Annual Report, August 1964.

TABLE 8.—BETA AND GAMMA EFFICIENCIES AND LIMITS OF DETECTABILITY, WASHINGTON MILK NETWORK

	Energy band (Mev)	Efficiency (percent)	Average background (pc) [*]	Limits of detectability (pc)
Gamma				
K[40]	1.37–1.55	0.18	2277	325
I[131]	0.33–0.40	4.20	300	20
Cs[137]	0.62–0.72	2.60	246	30
Ba[140]	0.46–0.57	3.50	326	30
Beta				
Y[90]	—	37	0.6	0.24

[*] Counts per minute expressed as pc.

Oxalic acid is then added to the sample to precipitate the alkaline earths as oxalates (pH 3.0). The oxalates are ashed, dissolved in 6 N hydroachloric acid, and the pH adjusted to 1.4. A double extraction using an equal volume of 20 percent di-(2-ethylhexyl) phosphoric acid (HDEHP) in toluene is performed. This effectively removes rare earth activity, including yttrium–90, leaving the strontium–90 in the sample. This sample is stored for a minimum of two weeks to allow yttrium–90 to ingrow. Subsequently, the yttrium–90 is extracted with 5 percent HDEHP in toluene. The organic layer is scrubbed with an HCl solution (pH 1.4) and back extracted with 3N HNO_3. The resulting nitric acid solution is evaporated and the yttrium–90 is counted. From this the strontium–90 activity is calculated. The yttrium–90 counting is done in a low-background gas-flow internal proportional counter.

As a part of the laboratory's quality control program, some samples are split and analyzed several times. Split samples are also exchanged with State, Federal, and university laboratories for analyses and comparisons.

Results

Table 9 presents the monthly average radionuclide concentrations in Washington raw milk for July through December 1964. The results are given for representative production areas within the major milksheds.

During this period the iodine–131 and barium–140 concentrations remained below detectable levels, except for two samples in November, as shown in table 10. These samples are presumed to reflect the mainland China atmospheric nuclear detonation of October 16, 1964.

Zinc–65 was observed on four occasions in Benton County between October 6 and November 13, 1964, (varying from 91 to 122 pc/liter). Zinc–65 was also observed in Franklin County on October 19, 1964, at a concentration of 91 pc/liter. This isotope has shown up routinely in these counties and results from irrigation of some pasture land with Columbia River water which, on occasion, has been shown to contain zinc–65.

In order to visualize general trends in strontium–90 and cesium–137 concentrations in Washington milk, monthly average network concentrations are presented graphically in figure 9. These averages are not weighted according to the volume of milk from each production area nor do they take into consideration the absence of samples from several stations for a particular month.
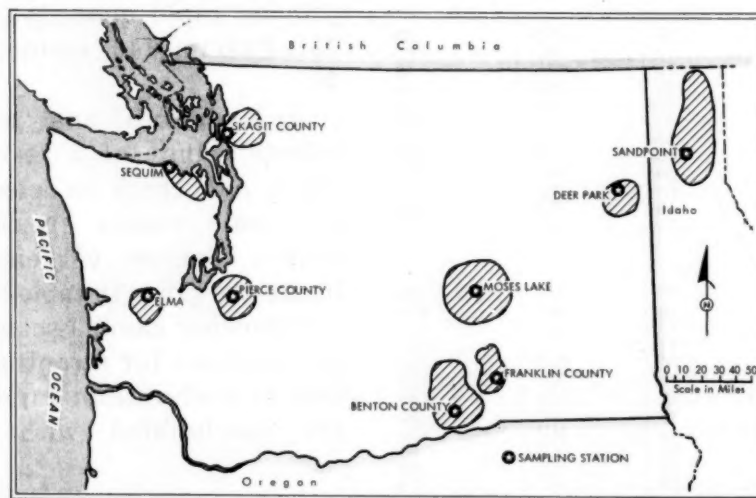

FIGURE 8.—WASHINGTON MILK SAMPLING LOCATIONS

Sampling station [b]	Potassium-40, pc/liter [a]					
	July	Aug	Sept	Oct	Nov	Dec
Benton Co	NS	1090	1160	1230 (2)	1220 (4)	1210
Deer Park	[e] NS	1180	1190 (2)	1230 (3)	1190 (4)	1230
Elma	1220	NS	1240 (2)	1280	1220 (3)	1240
Franklin Co	1230	NS	NS	1180	1150 (2)	NS
Moses Lake	NS	1140	1220 (2)	1190 (3)	1190 (4)	1160
Pierce Co	1270	NS	1150 (2)	1210 (3)	1200 (4)	1250
Sandpoint	NS	1230	1290 (2)	1250 (5)	1180 (6)	1270
Sequim	1230	NS	1200 (2)	1160 (3)	1120 (3)	1260
Skagit Co	1100	NS	1210 (2)	1160 (6)	1170 (6)	1080
Network average	1210	1160	1210	1200	1180	1210
Maximum	1270	1230	1340	1330	1350	1270
Minimum	1100	1090	1110	1110	1040	1080
	Strontium-90, pc/liter					
Benton Co	NS	[d] NA	9	NA	9	8
Deer Park	NS	15	20	13 (2)	22	26
Elma	22	NS	14	21	16	29
Franklin Co	8	NS	NS	9	NA	NS
Moses Lake	NS	7	10	8 (2)	8	8
Pierce Co	27	NS	29 (2)	20 (2)	16	18
Sandpoint	NS	31	34 (2)	30 (3)	28 (4)	20
Sequim	19	NS	12	13 (2)	17	21
Skagit Co	27	NS	10	25 (4)	23 (2)	20
Network average	21	18	20	19	21	19
Maximum	27	31	34	25	28	29
Minimum	8	7	9	7	8	8
	Cesium-137, pc/liter					
Benton Co	NS	73	71	50 (2)	69 (4)	45
Deer Park	NS	138	107 (2)	94 (3)	134 (4)	127
Elma	210	NS	103 (2)	122	91 (3)	182
Franklin Co	69	NS	NS	49	66 (2)	NS
Moses Lake	NS	46	59 (2)	49 (3)	55 (4)	56
Pierce Co	259	NS	300 (2)	144 (3)	119 (3)	71
Sandpoint	NS	209	204 (2)	148 (5)	161 (6)	148
Sequim	138	NS	74 (2)	71 (3)	114 (3)	119
Skagit Co	173	NS	100 (2)	128 (6)	108 (6)	143
Network average	169	117	131	104	107	111
Maximum	259	209	368	186	173	182
Minimum	69	46	56	35	45	45

[a] Parentheses indicate number of samples in average.
[b] All stations are in Washington except, Sandpoint, Idaho.
[c] NS indicates no sample collected.
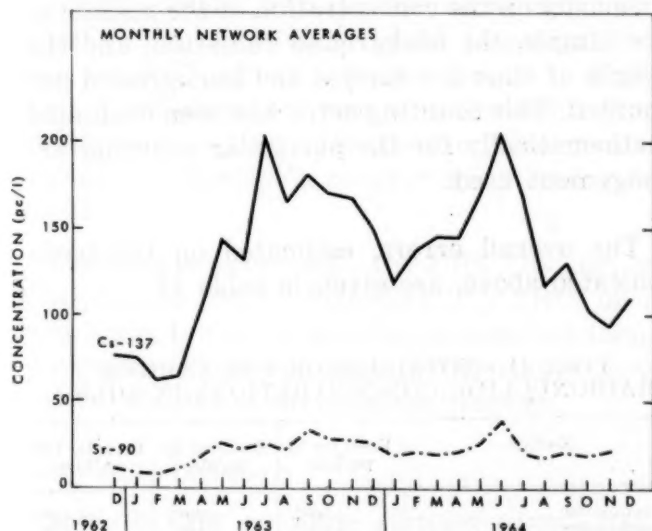[d] NA indicates no analysis performed.

FIGURE 9.—MONTHLY AVERAGE RADIONUCLIDE CONCENTRATIONS IN WASHINGTON MILK

Table 10.—MILK SAMPLES REFLECTING CHINESE TEST FALLOUT

Station	Date	Radionuclide concentrations	
		Iodine-131 (pc/liter)	Barium-140 (pc/liter)
Sequim	Nov. 10, 1964	12	<15
Skagit Co	Nov. 10, 1964	<10	17

5. Canadian Milk Network[4]
January 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and milk sampling locations (figure 10) may be chosen in the same areas as the air and precipitation stations. At present the analyses include determinations of iodine–131 strontium–89, cesium–137, and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. Each dairy contributes to the composite sample in proportion to its

FIGURE 10.—CANADIAN MILK SAMPLING
STATIONS

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted with the latter for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined, and the Compton contribution of this radionuclide to the cesium–137 photopeak is substracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137, and stable potassium and calcium.

Analytical methods

Radiochemical methods are used for the analysis of iodine–131 (8). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk. The milk is then placed in a tray (lined with a polyethylene sheet) and evaporated under infra-red lamps. The residue is placed in a muffle furnace at 450 degrees C. and the resulting ash dissolved in dilute nitric acid. Strontium is separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low-background beta counter. Strontium–90 is determined separately by extracting and counting its yttrium–90 daughter, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 11.

TABLE 11.—TOTAL ERROR FOR VARIOUS
RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±50%	±20%	±10%
Strontium-90	±15%	±10%	±10%
Iodine-131	±25%	±20%	±15%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 12 presents monthly averages of strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk.

TABLE 12.—STABLE ELEMENTS AND RADIONU-CLIDES IN CANADIAN WHOLE MILK, JANUARY 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pc/liter)	Cesium-137 (pc/liter)
Calgary	1.13	1.5	24.8	112
Edmonton	1.10	1.6	25.2	123
Ft. William	1.06	1.6	39.4	175
Fredericton	1.10	1.6	36.5	197
Halifax	1.06	1.6	35.4	231
Montreal	1.10	1.7	28.1	146
Ottawa	1.13	1.7	22.9	132
Quebec	1.04	1.6	43.3	247
Regina	1.06	1.6	33.7	130
St. John's, Nfld.	1.06	1.5	32.8	190
Saskatoon	1.13	1.6	26.9	115
Sault Ste. Marie	1.06	1.6	35.4	181
Toronto	1.08	1.7	14.2	90
Vancouver	1.15	1.6	38.1	261
Windsor	1.06	1.6	14.3	92
Winnipeg	0.84	1.7	27.3	163
Average	1.07	1.6	29.9	162

6. Pan American Milk Sampling Program, September 1963—December 1964

Pan American Health Organization, and Public Health Service

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service), developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, air sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963 this was expanded to include a milk sampling station in Caracas, Venezuela.

Between April 1964 and August 1964, milk stations were added in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde and sent to the PHS Southeastern Radiological Health Laboratory for biweekly compositing and analysis.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). To reduce spoilage it was necessary to establish cooling stations in the western parishes where the milk is received prior to shipping to the condensery in Kingston.

Analytical procedures

Iodine–131 and cesium–137 are determined by gamma scintillation spectroscopy. Strontium–89, strontium–90, and barium–140 are determined radiochemically. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation (on a percentage basis) is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interference from other radionuclides, and background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 (p. 250) shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 1 gives the 95-percent confidence limits between which the true concentrations of the selected radionuclides might be expected in the analyses. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable

concentration in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Ba^{140}, 10; Cs^{137}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error. Calcium analyses are done by an ion-exchange and permanganate titration method. Stable potassium concentrations are estimated from the potassium–40 concentrations[5] determined from the gamma spectrum.

Data presentation

Table 13 presents stable calcium and potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations in milk to date. Iodine–131 and barium–140 monthly average concentrations in milk are not tabulated because all were below 10 pc/liter. For comparison purposes the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico are presented.

Variations in cesium–137 levels between Montego Bay and Kingston (Spanish Town), Jamaica, have been attributed in part to differences in rainfall. The average rainfall in the Montego Bay milkshed is 75 to 200 inches, while in the other milksheds it ranges from 50 to 100 inches. Consideration of the farming practices leads to the conclusion that the differences in cesium levels can be attributed to a combination of environmental factors such as rainfall, soil leaching variations, and native grass differences.

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[5] The conversion factor is 1.18 x 10^{-3} g K/pc K^{40}.

TABLE 13.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN PAN AMERICAN MILK, AUGUST 1963–DECEMBER 1964

Sampling stations and months	Concentrations g/liter		Radionuclide concentrations, pc/liter		
	Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137
Canal Zone:					
Cristobal					
December 1964	1.16	1.4	<5	6	45
Jamaica:					
Kingston (1964)					
April	1.19	1.49	<5	24	345
May	* NS	NS	NS	NS	NS
June	1.18	1.35	<5	20	170
July	NS	NS	NS	NS	NS
August	NS	NS	NS	NS	NS
September	1.15	1.45	<5	12	165
October	NS	NS	NS	NS	NS
November	NS	NS	NS	NS	NS
December	1.24	1.39	<5	14	205
Mandeville (1964)					
July	1.20	1.42	<5	19	280
August	NS	NS	NS	NS	NS
September	NS	NS	NS	NS	NS
October	1.24	1.40	<5	13	265
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
Montego Bay (1964)					
May	1.24	1.42	<5	36	555
June	NS	NS	NS	NS	NS
July	NS	NS	NS	NS	NS
August	1.10	1.48	<5	16	660
September	NS	NS	NS	NS	NS
October	NS	NS	NS	NS	NS
November	1.21	1.35	<5	19	525
Puerto Rico:					
San Juan (1964)					
December	1.16	1.5	<5	10	50
Venezuela:					
Caracas (1963)					
August	1.14	1.40	10	5	15
September	1.13	1.45	<5	5	20
October	NS	NS	NS	NS	NS
November	1.18	1.38	<5	4	25
December	1.08	1.27	<5	6	30
1964					
January	1.16	1.39	<5	5	20
February	1.18	1.34	<5	6	25
March	1.10	1.54	<5	6	25
April	1.08	1.47	<5	6	35
May	1.15	1.46	<5	6	20
June	1.12	1.61	<5	6	25
July	1.10	1.44	<5	8	40
August	1.14	1.45	<5	5	30
September	1.12	1.54	<5	8	30
October	1.16	1.44	<5	6	20
November	1.18	1.36	<5	5	20

* NS indicates no sample collected.

REFERENCES

(1) PUBLIC HEALTH SERVICE. Summary of results from the raw milk sampling program, June 1957–April 1963. Rad Health Data 4:511–523 (October 1963).

(2) PUBLIC HEALTH SERVICE. Milk surveillance, pasteurized milk network, March 1964. Rad Health Data 5:309–317 (July 1964).

(3) PUBLIC HEALTH SERVICE. Pasteurized milk network, December and annual summary for 1964. Rad Health Data 6:193–202 (April 1965).

(4) CONNECTICUT STATE DEPARTMENT OF HEALTH. Connecticut Milk Network, January–December 1963. Rad Health Data 5:427 (September 1964).

(5) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium-90 in milk by an ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(6) PORTER, C., and B. KAHN. Improved determinations of strontium-90 in milk by an ion exchange method. Anal Chem 36:676–678 (March 1964).

(7) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(8) DASGUPTA, A. K., and H. G. GREEN. A method for the radiochemical determination of iodine-131 in milk. RPD-23, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, FEBRUARY 1964-JANUARY 1965

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) is reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the *PMN*. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3, 4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5".[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and a 1.0 g daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflect temporal and local deposition patterns (*6*).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

Sampling locations	Average radionuclide concentrations, pc/liter							
	Strontium-89		Strontium-90		Iodine-131		Cesium-137	
	Jan 1964–Dec 1964	Feb 1964–Jan 1965	Jan 1964–Dec 1964	Feb 1964–Jan 1965	Jan 1964–Dec 1964	Feb 1964–Jan 1965	Jan 1964–Dec 1964	Feb 1964–Jan 1965
Ala: Montgomery	3	3	22	22	0	0	79	76
Alaska: Palmer	5	5	21	20	0	0	124	115
Ariz: Phoenix	3	3	4	4	0	0	25	25
Ark: Little Rock	3	3	43	43	1	1	117	110
Calif: Sacramento	3	3	8	7	0	0	42	40
San Francisco	3	3	10	10	0	0	48	44
C. Z: Cristobal	3	3	5	5	0	0	51	50
Colo: Denver	3	3	19	19	0	0	88	85
Conn: Hartford	3	3	20	19	0	0	135	127
Del: Wilmington	3	3	22	22	1	1	113	108
D. C: Washington	3	3	19	19	0	0	79	75
Fla: Tampa	3	3	15	15	0	0	231	229
Ga: Atlanta	3	3	31	31	0	0	130	125
Hawaii: Honolulu	3	3	12	12	0	0	77	76
Idaho: Idaho Falls	10	9	26	25	0	0	154	146
Ill: Chicago	3	3	19	18	0	0	109	104
Ind: Indianapolis	3	3	20	19	1	1	91	87
Iowa: Des Moines	4	4	25	24	0	0	83	78
Kans: Wichita	4	4	21	20	0	0	63	60
Ky: Louisville	3	3	30	29	0	0	81	76
La: New Orleans	4	3	50	49	0	0	135	127
Maine: Portland	3	3	29	28	1	1	187	179
Md: Baltimore	3	3	22	22	0	0	90	86
Mass: Boston	3	3	31	30	0	0	203	192
Mich: Detroit	3	3	18	18	2	2	105	100
Grand Rapids	3	3	21	20	1	1	116	112
Minn: Minneapolis	7	6	31	30	0	0	135	127
Miss: Jackson	4	4	40	40	0	0	99	93
Mo: Kansas City	5	5	27	26	0	0	73	69
St. Louis	4	4	22	22	0	0	74	70
Mont: Helena	5	4	25	24	1	1	157	145
Nebr: Omaha	4	3	25	24	0	0	87	82
Nev: Las Vegas	3	3	10	9	1	1	70	66
N. H: Manchester	3	3	30	29	1	1	217	209
N. J: Trenton	3	3	19	18	1	1	109	104
N. Mex: Albuquerque	3	3	11	11	1	1	53	52
N. Y: Buffalo	3	3	20	19	0	0	131	126
New York	3	3	25	24	1	1	146	139
Syracuse	[e] 3	[d] 3	[e] 19	[d] 18	[e] 0	[d] 0	[e] 129	[d] 122
N. C: Charlotte	3	3	36	36	0	0	105	101
N. Dak: Minot	11	10	54	53	0	0	147	144
Ohio: Cincinnati	3	3	22	21	0	0	86	82
Cleveland	3	3	21	20	0	0	107	103
Okla: Oklahoma City	3	3	22	22	0	0	65	62
Ore: Portland	5	5	30	29	0	0	149	141
Pa: Philadelphia	3	3	20	19	0	0	110	103
Pittsburgh	3	3	29	28	0	0	138	133
P. R: San Juan	3	3	12	12	0	0	70	70
R. I: Providence	3	3	23	23	0	0	150	143
S. C: Charleston	3	3	32	32	0	0	122	119
S. Dak: Rapid City	5	5	39	38	0	0	142	138
Tenn: Chattanooga	4	4	40	40	0	0	111	105
Memphis	3	3	32	32	0	0	68	64
Tex: Austin	3	3	9	9	0	0	38	37
Dallas	3	3	19	19	0	0	58	55
Utah: Salt Lake City	6	6	25	24	0	0	165	159
Vt: Burlington	3	3	25	25	2	2	162	154
Va: Norfolk	3	3	18	18	0	0	88	85
Wash: Seattle	6	6	26	26	0	0	144	140
Spokane	6	5	28	26	0	0	132	128
W. Va: Charleston	3	3	25	25	0	0	73	68
Wis: Milwaukee	3	3	17	17	1	1	120	115
Wyo: Laramie	7	6	20	20	0	0	101	97
Network average	4	4	23.7	23.1	0	0	109	104

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 at each station were <10.
[b] Annual averages were computed on basis of 53 weekly averages.
[c] Annual averages were computed on basis of 48 weekly averages. No sample was collected during July 1964.
[d] Annual averages were computed on basis of 49 weekly averages. No sample was collected during July 1964.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

REFERENCES

(1) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961), price 20 cents.

(2) NATIONAL COMMITTEE ON RADIATION PROTECTION. Maximum permissible body burdens and maximum permissible concentrations of radio-nuclides in air and in water for occupational exposure. National Bureau of Standards Handbook 69, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (June 5, 1959).

(3) BUREAU OF CENSUS and PUBLIC HEALTH SERVICE. National Food Consumption Survey, fresh whole milk consumption in the United States, July 1962. Rad Health Data 4:15–17 (January 1963).

(4) BUREAU OF CENSUS and PUBLIC HEALTH SERVICE. Consumption of selected foods items in U.S. households, July 1962. Rad Health Data 4:124–129 (March 1963).

(5) FEDERAL RADIATION COUNCIL. Estimates and evaluation of fallout in the United States from nuclear weapons conducted through 1962, Report No. 4. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1963).

(6) FEDERAL RADIATION COUNCIL. Revised fallout estimates for 1964–1965 and verification of the 1963 predictions, Report No. 6. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (October 1964).

STRONTIUM-90 IN 1964 UNITED STATES WHEAT

V. F. Pfeifer and R. A. Anderson[1]

Studies of processing methods aimed at reducing strontium-90 in wheat and milling products are continuing at the U.S. Department of Agriculture's Northern Regional Research Laboratory. Kansas wheats from the 1963 crop year are being used in these experiments because their strontium-90 levels were the highest yet reported. Strontium-90 levels in 1963 wheats from the major U.S. wheat-producing areas, reported last year by Pfeifer and Peplinski (1), agreed quite well with the average of 250 pc/kg predicted by the Federal Radiation Council (2). At that time a value of 100 pc/kg was predicted as the probable average for 1964 wheat. This prediction was subsequently raised to 140 pc/kg based on later data for fallout and accumulation of strontium-90 in the soil at the beginning of 1964 (3).

A total of 77 wheat samples from the 1964 harvest was procured from 31 different locations in 11 different wheat-producing States. These 11 States represent 69 percent of the total 1964 wheat production (4). Each lot of wheat was blended and cleaned in a dockage tester to remove dust and chaff before analysis. Strontium-90 was determined by a modification of the method described by Harley (5). The samples were ashed at 1000°F; the ash was fused with sodium carbonate at 1700°F; strontium carrier was added to the suspension of fusion mixture in hot water; and insoluble carbonates were separated, washed, and recovered. The carbonates were dissolved in nitric acid, and strontium nitrate recovered after two purifications in 75 percent nitric acid, yttrium-90 was stripped out as the hydroxide with yttrium carrier, and strontium-90 with strontium carrier was recovered by carbonate precipitation. Strontium-90 was determined from a 2-week ingrowth of its daughter, yttrium-90. Analyses for protein, ash, and calcium were made by Cereal Laboratory Methods 46–10, 08–01, and 40–20, respectively (6).

The results, listed in table 1, show lowest levels of contamination in wheat from Washington, Oregon, Idaho, Montana, and North

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TABLE 1.—STRONTIUM-90 IN U.S. WHEATS
HARVESTED IN 1964

(Calculated on dry basis [a])

Wheat class	Grown in vicinity of:	Number of samples	Nitrogen (per cent)	Ash (per cent)	Calcium (per cent)	Strontium-90 (pc/kg)
SWW [b]	Rosalia, Wash	1	1.62	1.47	0.040	91
HRW	Southeast Washington	5	2.56	1.59	—	55
HRW	North Central Oregon	2	2.21	1.78	—	53
HRW	Bonners Ferry, Idaho	1	2.35	1.61	—	41
HRW	Southern Idaho	2	2.66	1.58	—	26
HRS [c]	Cut Bank, Mont	1	2.56	1.58	0.037	132
HRS	Dutton, Mont	1	2.55	1.89	0.032	37
HRS	Bozeman, Mont	1	3.46	2.03	0.055	30
HRS	Williston, N. Dak	1	2.99	2.12	0.038	81
HRS	Carrington, N Dak	4	3.00	1.98	0.031	102
HRS	Langdon, N. Dak	1	3.06	2.23	0.036	121
HRS	Fargo, N. Dak	1	2.97	2.20	0.044	34
HRW [d]	Alliance, Nebr	5	2.88	1.62	0.045	81
HRW	Lincoln, Nebr	5	2.80	1.91	0.054	226
HRW	Garden City, Kans. (Irrigation)	5	2.57	1.73	0.055	181
HRW	Garden City, Kans. (Dry land)	6	2.93	1.88	0.056	159
HRW	Kinsley, Kans	3	2.59	2.00	0.061	227
HRW	Hays, Kans	6	2.88	1.60	0.057	232
HRW	Hutchinson, Kans	6	2.77	1.47	0.053	138
HRW	Newton, Kans	6	2.65	1.71	0.046	226
HRW	Manhattan, Kans	6	3.12	1.74	0.052	310
HRW	Peoria, Ill	2	2.09	1.95	0.049	142
SWW	Saranac, Mich	1	1.77	1.73	0.039	120
SWW	Elsie, Mich	1	2.14	2.10	0.042	139
SRW [e]	Lafayette, Ind	2	2.57	1.85	0.051	170
SRW	Wooster, Ohio	2	2.46	1.81	0.040	224

[a] Wheat moisture contents varied from 7.7 to 12.9 percent.
[b] SWW indicates soft white winter wheat.
[c] HRS indicates hard red spring wheat.
[d] HRW indicates hard red winter wheat.
[e] SRW indicates soft red winter wheat.

Dakota, and highest levels in wheat from Kansas and Ohio. The individual values ranged from a low of 26 pc/kg (dry basis) for hard red winter wheats grown in southern Idaho, to a high of 380 for an Ottawa variety of hard red winter wheat harvested near Manhattan, Kansas. The table shows large variations in levels of strontium-90 for wheats grown in the same State at different locations not too far apart. The mean values for Kansas included at least three samples from each location; for Nebraska, five samples from each location; and for Carrington, North Dakota, four samples. Standard deviations were less than 20 percent of the mean at each individual location, with most of this deviation apparently due to variety differences within the location.

Although the sampling is probably inadequate for a precise calculation of the average strontium-90 content of 1964 U.S. wheat, the results permit a reasonable estimate to be made. Projecting the values for the individual State averages (average of locations within a State), weighted by the 1964 production figures (4) to the entire 1964 wheat crop, the average is 133 pc/kg (dry basis) or 120 pc/kg (as-is basis). This estimate compares well with the Federal Radiation Council's predicted average value of 140 pc/kg (as-is basis) for 1964 U.S. wheat and confirms its prediction of a substantial reduction below 1963 levels.

Acknowledgments

REFERENCES

(1) PFEIFER, V. F., and A. J. PEPLINSKI. Strontium-90 in 1963 United States Wheat. Rad Health Data 5:283–284 (June 1964).

(2) FEDERAL RADIATION COUNCIL. Estimates and evaluation of fallout in the United States from nuclear weapons testing conducted through 1962. Report No. 4, p. 17, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1963), price 30 cents.

(3) FEDERAL RADIATION COUNCIL. Revised fallout estimates for 1964–1965 and verification of the 1963 predictions. Report No. 6, p. 27, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (October 1964), price 25 cents.

(4) CROP REPORTING BOARD, STATISTICAL REPORTING SERVICE. Annual crop summary CR-PR2-1(64), p. 60. U.S. Department of Agriculture, Washington, D.C. 20250 (December 18, 1964).

(5) HARLEY, J. H. Radiochemical determination of strontium-90. JOAC 46:371–380 (1963).

(6) AMERICAN ASSOCIATION OF CEREAL CHEMISTS. Cereal Laboratory Methods, 7th ed. The Association, St. Paul, Minnesota (1962).

Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, NOVEMBER 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 131 stations as of January 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (1–7).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on either monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short term radioactivity effects from current or recent nuclear tests or events.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Strontium–90 analyses are performed on total solids of three-month composites of the weekly samples. The most recent strontium–90 results are presented in the March 1965 *RHD*.

Analytical methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard

Methods for the Examination of Water and Wastewater" (8). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Results

Table 1 presents November 1964 results of alpha and beta analysis of U.S. surface waters.

The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (7). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 it is reported as <1 pc/liter.

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, NOVEMBER 1964

Station	Beta activity, pc/liter			Alpha activity, pc/liter			Station	Beta activity, pc/liter			Alpha activity, pc/liter		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							Cape Girardeau, Mo...	4	21	25	0	1	1
Cedar Hill, N. Mex..	0	13	13	0	2	2	Vicksburg, Miss....	8	12	20	2	1	3
Apalachicola River:							New Roads, La....	16	11	27	4	2	6
Chattahoochee, Fla..	2	5	7	0	0	0	New Orleans, La...	1	17	18	0	2	2
Arkansas River:							Missouri River:						
Coolidge, Kansas....	9	30	39	1	19	20	Williston, N. Dak..	0	16	16	0	7	7
Ponca City, Okla....	24	17	41	1	5	6	Bismark, N. Dak...	2	28	30	2	3	5
Atchafalaya River:							Yankton, S. Dak...	6	29	35	1	3	4
Morgan City, La....	340	9	349	80	3	83	St. Joseph, Mo...	15	21	36	5	4	9
Bear River:							North Platte River:						
Preston, Idaho......	0	8	8	0	1	1	Henry, Nebr........	5	42	47	1	27	28
Big Horn River:							Ohio River:						
Hardin, Mont......	2	15	17	1	9	10	Cairo, Ill.........	5	14	19	1	1	2
Big Sioux River:							Toronto, Ohio.....	5	23	28	0	1	1
Sioux Falls, S. Dak..	2	28	30	0	4	4	Pend Oreille River:						
Chattahoochee River:							Albeni Falls Dam,						
Atlanta, Ga......	4	8	12	<1	0	<1	Idaho...........	0	7	7	0	1	1
Columbus, Ga......	1	7	8	0	0	0	Platte River:						
Lanett, Ala......	2	6	8	<1	0	<1	Plattsmouth, Nebr..	22	19	41	5	5	10
Chena River:							Potomac River:						
Fairbanks, Alaska....	0	6	6	0	1	1	Washington, D.C....	0	5	5	0	1	1
Clinch River:							Red River, North:						
Clinton, Tenn......	4	8	12	0	0	0	Grand Forks, N.						
Kingston, Tenn.....	5	58	63	0	0	0	Dak...........	4	36	40	0	2	2
Colorado River:							Red River, South:						
Loma, Colo........	14	0	14	2	7	9	Alexandria, La.....	16	11	27	5	2	7
Page, Ariz........	2	30	32	0	6	6	Rio Grande:						
Parker Dam, Calif-							El Paso, Tex.......	2	23	25	3	5	8
Ariz............	1	22	23	0	13	13	Laredo, Tex.......	6	10	16	1	2	3
Columbia River:							Sacramento River:						
Wenatchee, Wash....	1	8	9	0	1	1	Greens Landing,						
Pasco, Wash........	45	660	705	0	1	1	Calif...........	4	8	12	0	<1	<1
Clatskanie, Ore.....	17	121	138	0	<1	<1	San Joaquin River:						
Connecticut River:							Vernalis, Calif.....	5	0	5	0	3	3
Enfield Dam, Conn..	4	9	13	0	0	0	San Juan River:						
Coosa River:							Shiprock, N. Mex..	62	26	88	5	10	15
Rome, Ga..........	5	6	11	1	0	1	Savannah River:						
Cumberland River:							Port Wentworth, Ga.	5	10	15	<1	0	<1
Cheatham Lock,							Snake River:						
Tenn.............	0	4	4	0	0	0	Wawawai, Wash....	2	6	8	0	3	3
Delaware River:							South Platte River:						
Philadelphia, Pa.....	7	10	17	2	0	2	Julesburg, Colo....	14	57	71	3	32	35
Escambia River:							Tennessee River:						
Century, Fla........	3	7	10	0	0	0	Lenoir City, Tenn..	2	6	8	0	0	0
Great Lakes:							Chattanooga, Tenn..	2	9	11	<1	0	<1
Duluth, Minn......	0	6	6	0	0	0	Bridgeport, Ala.....	3	9	12	1	0	1
Hudson River:							Pickwick Landing,						
Poughkeepsie, N.Y..	0	21	21	0	2	2	Tenn...........	1	8	9	<1	1	<2
Illinois River:							Tombigbee River:						
Grafton, Ill........	8	9	17	1	2	3	Columbus, Miss....	10	9	19	3	0	3
Kansas River:							Wabash River:						
De Soto, Kans......	8	18	26	4	0	4	New Harmony, Ind.	3	11	14	<1	1	<2
Maumee River:							Yellowstone River:						
Toledo, Ohio........	1	87	88	0	0	0	Sidney, Mont.......	2	14	16	1	6	7
Mississippi River:													
St. Paul, Minn.....	0	22	22	1	2	3	Maximum...........	340	660	705	80	32	83
Dubuque, Iowa.....	2	19	21	0	<1	<1							
E. St. Louis, Ill.....	0	18	18	1	1	2	Minimum...........	0	0	4	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report.

FIGURE 1.—SAMPLING LOCATIONS AND ASSOCIATED TOTAL BETA ACTIVITY
(pc/liter) IN SURFACE WATERS, NOVEMBER 1964

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1 which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for the years 1957–1962 have been summarized by Weaver et al (9).

Discussion

The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (10). The Public Health Service Drinking Water Standards state that in the absence of strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pc/liter (11).

The monthly average dissolved beta activities were below 100 pc/liter at all but two stations. These results were found on the Columbia River: Pasco, Washington and Clatskanie, Oregon had values of 660 and 121 pc/liter respectively.

REFERENCES

(1) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, price $1.50.
(2) Ibid., 1959 Edition. Price $1.75.
(3) Ibid., 1960 Edition.[2]
(4) Ibid., 1961 Edition.[2]
(5) Ibid., 1962 Edition.[2]
(6) Ibid., 1963 Edition (in press).
(7) Ibid., 1964 Edition (to be published).
(8) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater. 11th Edition, New York (1960).
(9) WEAVER, L., A. W. HOADLEY, and S. BAKER. Radioactivity in surface waters of the United States, 1957–1962. Rad Health Data 4: 306–16 (June 1963).
(10) STRAUB, C. P. Significance of radioactivity data, JAWWA 53: 704 (June 1961).
(11) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium–90 respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

Section IV—Other Data

THE DENTAL SURPAK PROGRAM AND RESULTS THROUGH DECEMBER 1963

James W. Miller[1]

One of the first tasks of the Public Health Service's Division of Radiological Health, when it was formed in 1958, was to develop plans for a nationwide comprehensive radiological health program to be conducted in cooperation with State health agencies, professional organizations representing the healing arts, and with other Federal agencies. Among the principal sources of ionizing radiation encompassed in these plans were X-ray machines of all types, nuclear reactors and their radioactive by-products, high energy particle accelerators, concentrated forms of naturally-occurring radioactive materials, and fallout resulting from detonation of nuclear devices. The task was complicated by a critical shortage of individuals well trained in radiation control methods at all levels of government.

A large percentage of the manmade radiation exposure received by the U.S. population today

is attributable to the use of X-ray machines by the health professions. Of the estimated 200,000 X-ray machines in this country, approximately 100,000 are owned and operated by dentists. The X-ray machines under the control of the dental profession expose about 185,000,000 dental films a year. While the possible contribution to somatic and genetic exposure arising from dental radiography is considerably less than that from medical sources (*1, 2*), a conservative assumption is that the somatic and genetic effects resulting from radiation insult have no threshold and that a direct linear relationship exists between dose and biological effect (*3*). Thus, in general, any exposure of an individual or a population group to ionizing radiation involves some risk, and the benefits resulting from such an exposure must be weighed against the risk involved. No matter how small the present radiation exposure is to the patient or to the occupationally-exposed person, if it can be reduced without adversely affecting the clinical results, every reasonable effort should be made to accomplish this reduction.

[1] Dr. Miller is presently Chief of the Medical X-ray Program and was previously Chief of the Dental X-ray Program, State Assistance Branch, Division of Radiological Health.

Studies conducted in larger centers of population by interested parties and agencies following the 1956 report of the National Academy of Sciences (4) indicated that a large percentage of the dental X-ray machines in this country did not meet recommendations set forth by either the National Committee on Radiation Protection and Measurements (5) or the American Academy of Oral Roentgenology (6).

Initial X-ray control activity in many States started with radiation surveys of dental X-ray machines. Attention was given to dental X-ray machines, not because they were the greatest source of unnecessary population exposure, but for the following reasons:

1. There are fewer variables in dental equipment, thereby making them easier to inspect than X-ray machines in use by other health professions.
2. Dental X-ray equipment defects lend themselves to relatively simple detection, modification and/or correction.
3. A significant reduction in exposure could be accomplished from the correction of dental X-ray equipment.
4. The dental profession as a whole was extremely interested in and receptive to a program to correct equipment deficiencies.
5. Almost half of the X-ray machines in this country are used by dentists.
6. Due to the newness of the field, there was a lack of trained or knowledgeable personnel and a lack of experience in carrying out X-ray control programs.
7. Experience and information gained from dental X-ray control programs could be applied to more complex problems in the development of a comprehensive program dealing with all phases of radiological health.

With the limited number of people available and the large number of X-ray machines to check, office visits alone were impractical to identify defective equipment within a reasonable period of time. Some technique other than the office visit was needed to accomplish this. The Public Health Service's Division of Radiological Health devised the dental X-ray mail-order film step-wedge survey packet, commonly known as the "dental Surpak" (7).

Survey Method

The Surpak is a device that enables the practicing dentist to cooperate with his state health agency in determining whether his X-ray unit has characteristics which contribute to unnecessary radiation exposure.

This simplified procedure is useful primarily in assessing factors that affect X-ray exposures of dental patients rather than operators. Since factors reducing patient exposure can also reduce exposure of operating personnel, the procedure may also provide clues to the occupational doses of the dentist and his assistant. This method will assist materially in indicating the need for reducing unnecessary patient and occupational exposure, but will not completely remove the need for a physical inspection. Additionally, it can serve as an aid in surveying areas not readily reached by health department personnel, locating priority needs, and as a method of followup and evaluation after recommended improvements reportedly have been made.

The complete Surpak consists of three parts:
1. A mailing envelope. This envelope has the health agency's address imprinted in the upper left-hand corner.
2. A return-mail envelope. This envelope has the health agency's address imprinted in the center of the face of the envelope.
3. The Surpak itself in a sealed envelope. On the face of this envelope will be found a code number, general instructions, and spaces to be filled in by the dentist in reference to his particular X-ray machine(s). Inside is a slow industrial 8 x 10-inch X-ray film with lead backing, an aluminum step-wedge and a lead code number (See figure 1).

The general instructions direct the dentist to lay the film envelope face up on a flat horizontal surface with the pointer cone positioned perpendicularly to the Surpak so that the end of the cone touches the center of the circle on the envelope. The exposure is then made according to a printed schedule on the envelope, and returned in the envelope provided. The spaces to be filled in are labeled according to location (county and city), manufacturer, model number, tube housing serial number, console serial number, and data for the exposure (pointer cone used, kilovolt peak, tube current, exposure time, and date).
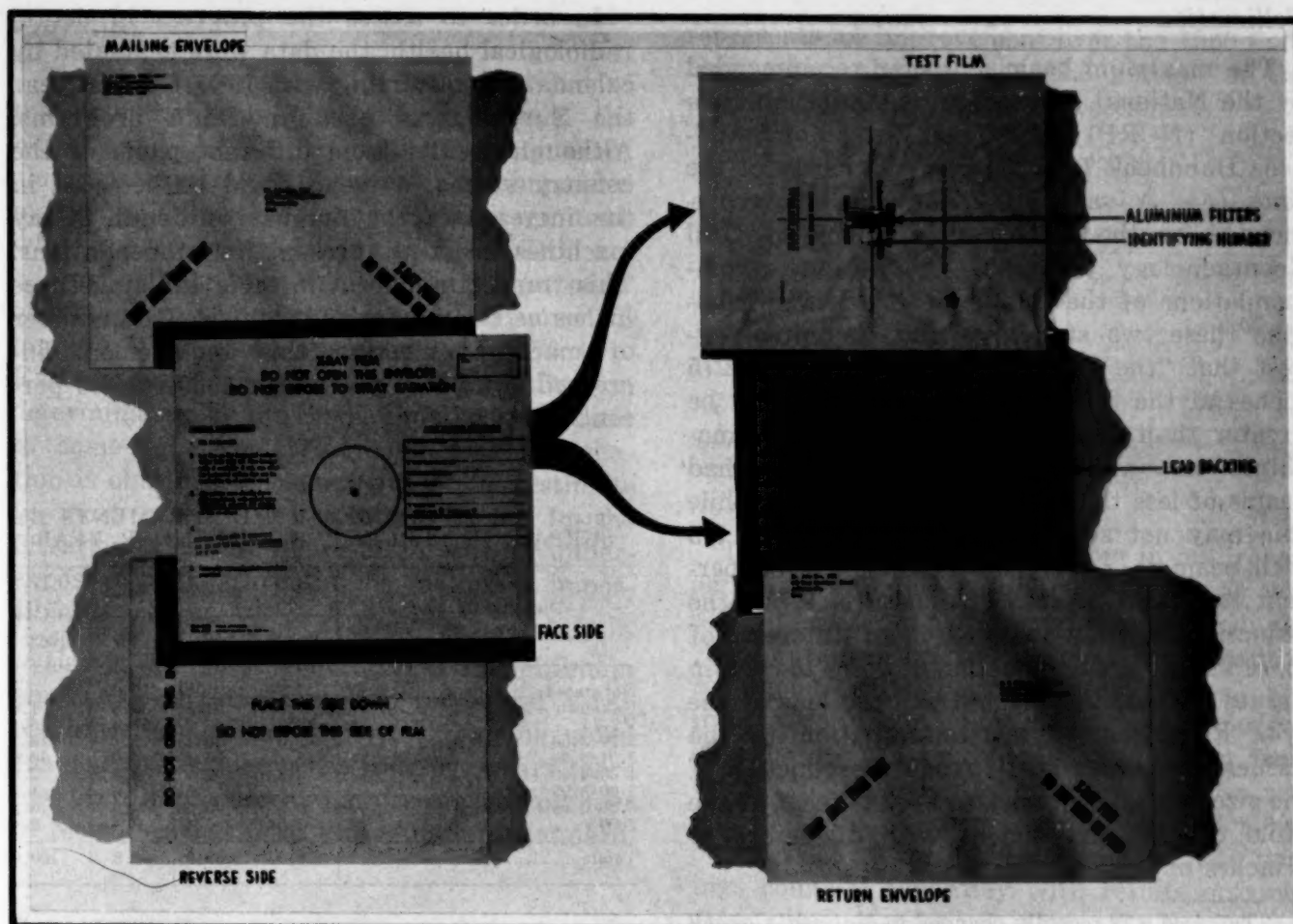
FIGURE 1.—THE DENTAL SURPAK

The name and address of the dentist does not appear on any Surpak. The health agency assigns a code number to each participating dentist and mails a complete Surpak to him. The participating dentist, in turn, fills in the blanks, exposes the Surpak as instructed, and returns it by mail to the health department (see figure 2). This takes just a few moments of his time. The exposed Surpaks are then returned by the health agency to the Public Health Service Radiological Health Laboratory, Rockville, Maryland, for controlled processing and interpretation (8).

Specific information provided by a properly exposed Surpak for a specific X-ray machine includes the size of the beam at the end of the pointer cone, the approximate roentgen output in mr/mas, total filtration (inherent and added), beam symmetry, and leakage radiation in the direction of a patient's face.

Information obtained from the processed film is transferred to data processing punch cards from which a list of findings is prepared, and returned to the local health departments. Each health department in turn notifies the participating dentists of the results obtained and if needed, makes recommendations as to corrective procedures required to bring their X-ray machines up to recommended standards if needed.

Surpak Survey Results

A total of 58,000 Surpaks had been distributed to 39 States as of June 30, 1964. Of the States that have used the Surpak in their programs, 27 have completed their initial survey in the sense that 65 to 95 percent of the dentists cooperated on a voluntary basis. The mode is 80 percent voluntary cooperation on a national basis. Results from 40,810 Surpaks returned by December 30, 1963 provided the following information.

Collimation

The maximum beam diameter recommended by the National Committee on Radiation Protection[2] (NCRP) in National Bureau of Standards Handbook 76 is 3 inches at the tip of the cone (5). A value of 2.75 inches is recommended by the American Academy of Oral Roentgenology (AAOR). The present recommendations of the Public Health Service combine these two standards and currently suggest that "the beam diameter should be 2.75 inches at the tip of the cone and shall not be greater than 3 inches." The majority of machines not meeting present standards had beams of less than 4 inches in diameter. While this may not seem excessive, reducing a 3.5 inch beam to 2.75 inches results in a 38 percent reduction in area of exposure. While the reduction in area exposed is of interest, of more import is the reduction of doses to certain tissues such as the thyroid and the lens of the eye. Reduction of scatter radiation to the tissues would also result from the reduction of the size of the X-ray beam. Five percent of the units checked had beams with diameters of 4 inches or more.

[2] The name was recently changed to *National Council on Radiation Protection and Measurements.*

In order to assess the progress in dental radiological health, the data were evaluated by calendar year, starting with 1960, the first year the Surpak was used in State programs. Although results from different parts of the country varied, a trend could be detected in the increase in the number of dental X-ray machines meeting present recommendations. This trend is apparent in table 1. Using three inches as the maximum beam size, the number of machines meeting this requirement increased from 45.2 percent in 1960 to 63.6 percent in 1963.

TABLE 1.—BEAM DIAMETER MEASUREMENTS BY SURPAK, IN PERCENT, BY CALENDAR YEAR

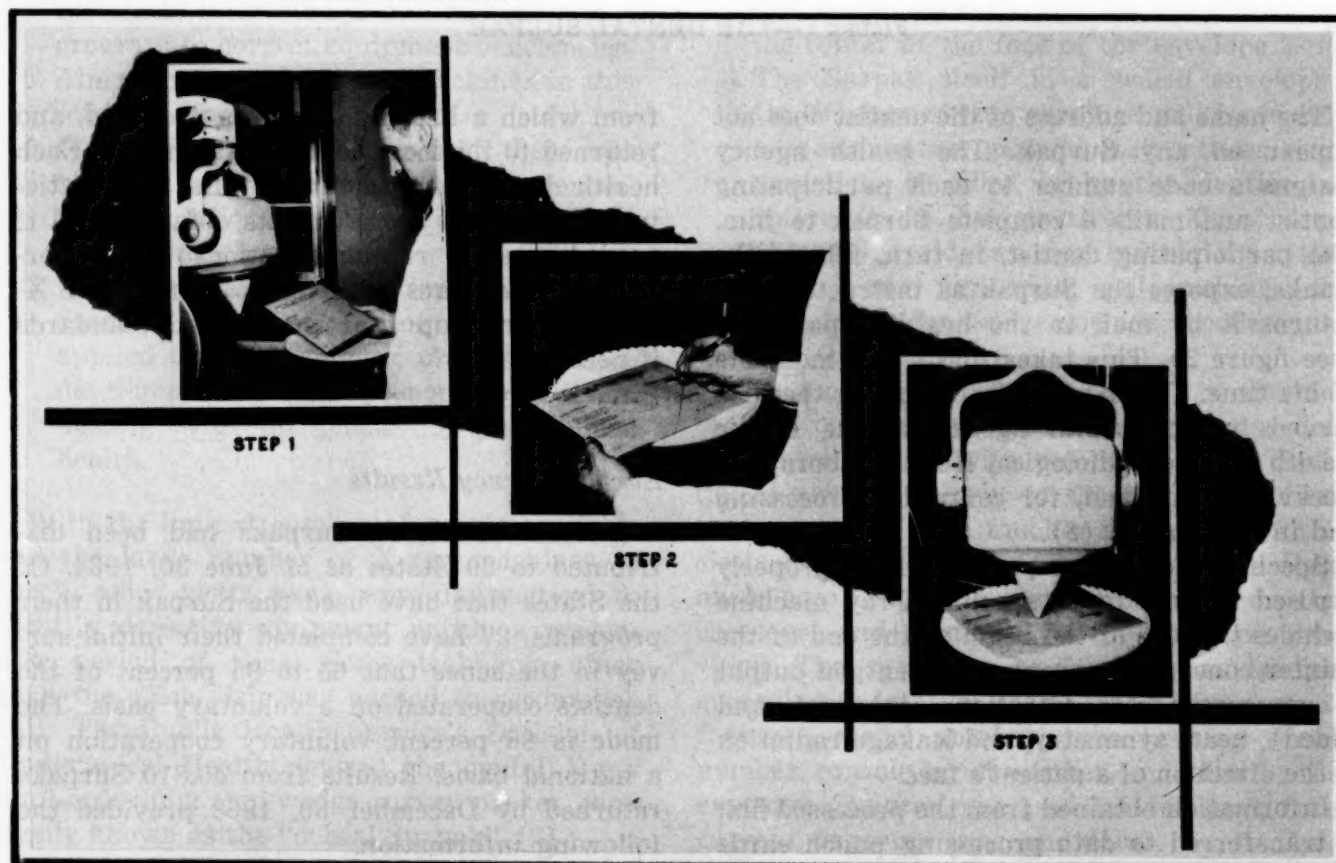| Diameter (inches)	Percent by years			
	1960	1961	1962	1963
Not stated			0.02	
Unknown	1.2	1.8	0.8	1.0
≦2.75	32.7	43.0	47.2	45.4
2.76–3.00	12.5	13.4	12.7	18.2
3.01–3.99	48.1	36.6	34.0	30.6
4.00–4.99	3.3	2.7	2.5	2.6
5.00–5.99	1.6	1.5	1.6	1.3
6.00–6.99	0.5	0.5	0.5	0.5
7.00+	0.08	0.4	0.4	0.4
Total	100.0	99.9	99.8	100.0

FIGURE 2.—THE USE OF THE SURPAK

Filtration

The recommendations for total filtration of the primary beam also differs between the NCRP and AAOR. A total of 2.0 mm of aluminum equivalent filtration is recommended by the AAOR, regardless of kilovoltage used, while the recommendations of the NCRP are 1.5 mm of aluminum equivalent for equipment operating up to and including 70 kvp and 2.5 mm total for those operating above 70 kvp. Even though the accuracy of the filtration determination by the Surpak method is subject to some inherent errors, sufficient information is obtained to make a reasonable estimate in most cases. The unknown values in the filtration tables are the result of over- or under-exposure of the Surpak films, making it impossible to estimate.

Using 1.5 mm of aluminum as the minimum amount of filtration required for dental X-ray machines regardless of kvp, it can be noted (table 2) that during the last four years there has been a 20 percent increase in the number of machines that meet this minimum standard.

TABLE 2.—SURPAK RESULTS: TOTAL FILTRATION IN PERCENT, BY CALENDAR YEAR

Degree of filtration	Percent of surveys, by years			
	1960	1961	1962	1963
Unknown	5.9	15.6	14.9	10.8
<1.5 mm	51.9	38.2	29.7	29.0
≥1.5	42.2	46.2	55.4	60.2
Total	100.0	100.0	100.0	100.0
Total number of surveys *	1,137	12,243	13,873	7,557

* Does not include resurveys.

Collimation and filtration

Usually the number of machines which meet the recommendations for both filtration and collimation are reported in the literature. This information is presented in table 3. The percentage of machines needing correction when 2 safety features are used is substantially higher than when only one is used. In general, 70 percent of the dental X-ray machines checked for the first time today by the Surpak method would require correction in order to meet present requirements for both filtration and collimation when initially inspected. This represents an improvement over the 1960 findings, which showed that 82.5 percent of the machines required these corrections.

TABLE 3.—DENTAL SURPAK FILTRATION AND COLLIMATION RESULTS

Collimation (in inches)	Total filtration (mm aluminum equivalent)	Percentages observed, by years			
		1960	1961	1962	1963
≤3.00″	Unknown	5.8	16.0	15.0	10.8
	<1.5	13.9	14.1	11.0	10.8
	≦1.5	17.5	23.6	30.2	30.5
>3.00″	<1.5	37.9	23.8	18.5	18.1
	≧1.5	24.7	22.2	25.0	29.5
	Total	99.8	99.7	99.7	99.7

Roentgen output

The output of the useful beam in milliroentgens per milliampere second (mr/mas) was determined from net densities read from the exposed film converted to relative exposure in roentgens using appropriate graphs and information recorded on the face of the Surpak envelope by the dentist. As can be seen from table 4, 66.1 percent of machines have an output of under 2 roentgens per second when operated at 10 ma (200 mr/mas). These findings compare favorably with results obtained from other inspections where the output was measured using more refined methods, such as a Victoreen Condenser-r-meter.

TABLE 4.—ROENTGEN OUTPUT DETERMINED BY SURPAK

Roentgen output (mr/mas)	Number	Percent
Unknown	9,753	23.9
000–099	10,770	26.4
100–199	16,182	39.7
200–299	3,595	8.8
300–399	350	0.9
400–499	77	0.2
>500	83	0.2
Total	40,810	100.0

Primary leakage

For purposes of the Surpak, this is defined as primary radiation discernable on the 8 x 10-inch film that is not limited to the area of the useful beam at the tip of the pointer cone. This may in some cases be due to poorly-fitting or loose collimators. Table 5 shows the number and percentage of machines having primary leakage. While the percentage of machines having leakage in the anterior direction is small, this source of unnecessary radiation could not be readily detected by other survey methods.

TABLE 5.—ANTERIOR PRIMARY LEAKAGE DETERMINED BY SURPAK

Primary leakage	Number	Percent
Unknown	628	1.5
Yes	1,241	3.0
No	38,941	95.4
Total	40,810	99.9

Corrections

The Surpak has proved to be a very valuable tool in identifying equipment in need of correction. Faced with the shortage of trained personnel to follow up on defective units, health agencies wanted to know how they could correct these machines. Experience from limited studies in which recommendations were made to bring X-ray machines up to standards showed that upon follow-up surveys, less than 30 percent of the initially defective units had been corrected. Many reasons for this non-compliance with recommended standards were identified, but the most fundamental reason was that the necessary filters and collimators were not readily available. It was felt that if these materials were provided and the dentist made aware of why and how to install the corrective devices, he would cooperate. On this premise the Public Health Service produced suitable filters and collimators and made them available to dentists through State health departments.

Five manufacturers of dental X-ray machines were identified as the source of more than 92 percent of all units in use in this country. Enough filters and collimators to correct 70,000 of these five most common X-ray machines have been distributed to health agencies by the Public Health Service. In addition to providing filters and collimators, a booklet was also developed by the Public Health Service entitled "Radiation Protection for Dentist and Patient" (Public Health Service Publication No. 885). Its contents explain simply the "Why" and "How" of radiological health in the dental office, and the methods of equipment correction. To date, 95,000 of these booklets have been distributed. With these tools, health agencies have additional resources to correct the major machine deficiencies by mail.

By 1962, several States had progressed to a point in their program where the original Surpak data had been evaluated and recommendations for correction had been sent to the dentists. In most cases, the State health department had sent the individual practitioner the lead collimators and aluminum filters necessary to bring most X-ray machines into compliance with established standards for filtration and collimation. After a period of time, a follow-up Surpak was sent to the dentist to determine whether the lead collimator and aluminum filters were being used. The results of these resurveys varied according to the effort that the health departments and the dental societies made to obtain compliance, but a persistent gain in the number meeting recommended standards is indicated.

During 1962 and 1963 as a result of this mail order survey and follow-up program, 80 percent of the dental X-ray machines found not meeting recommended standards for beam diameter at the time of the original survey were brought into compliance.

Summary and conclusions

The "Dental Surpak" was devised by the Division of Radiological Health as a method of identifying dental X-ray units which contribute to unnecessary radiation exposure.

A total of 58,000 Surpaks had been distributed to 39 States as of June 30, 1964. Of the States that have used the Surpak, 27 have completed their initial survey. Results from over 40,000 of these surveys indicate that 60 to 80 percent of the units inspected for the first time would not meet recommended standards for filtration and collimation. During 1962 and 1963, an average of 80 percent compliance in X-ray machines originally found to be below standards was obtained by this dental mail-order survey and correction method.

The "Dental Surpak" has proven to be a valuable public health tool. The correction of filtration and collimation defects identified through its use has resulted in a substantial decrease in the dental contribution to population radiation exposure.

REFERENCES

(1) LINDELL, B. and L. R. DOBSON. Ionizing radiation and health. World Health Organization Public Health Paper, No. 6, Geneva (1961).
(2) COMMITTEE ON RADIOLOGICAL HAZARDS TO PATIENTS. Radiological hazards to patients—second report of the committee. Her Majesty's Stationery Office, London (1960), price six shillings.
(3) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, report no. 1, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960), price 30 cents.
(4) NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL. The biological effects of atomic radiation, summary reports. Washington, D.C. (1956).

(5) NATIONAL COMMITTEE ON RADIATION PROTECTION AND MEASUREMENTS. Medical X-ray protection up to three million volts. National Bureau of Standards Handbook 76, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (February 9, 1961), price 35 cents.
(6) RICHARDS, A. G. et al. X-ray protection in the dental office. J Amer Dent Ass 56:514–521 (April 1958).
(7) U. S. PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. The dental Surpak survey method. Rad Health Data 4:46–49 (January 1963).
(8) WINKLER, K. A film method for determining peak kilovoltage, total filtration and roentgen output of an X-ray machine (in preparation).

RADIONUCLIDES IN ALASKAN CARIBOU AND REINDEER, 1963–1964

Division of Radiological Health, Public Health Service

A new phase in assessing the radionuclide intake of Alaskan residents began in 1963, when caribou and reindeer sampling and analysis were undertaken by the Alaskan Departments of Health and Welfare and of Fish and Game, and the Public Health Service, under a cooperative agreement between these agencies. The basis for this joint activity stemmed from a more limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou (*Rangifer caribou*) herds and one privately owned reindeer (*Rangifer tarandus*) herd. This program was expanded when, beginning in September 1964, the sampling of additional privately-owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and Bureau of Indian Affairs, Department of Interior.

Figure 1 shows the locations and approximate number of animals in the caribou and reindeer herds sampled. In general, the reindeer herds are located on or near the Seward peninsula and on two islands off the western coast of Alaska.
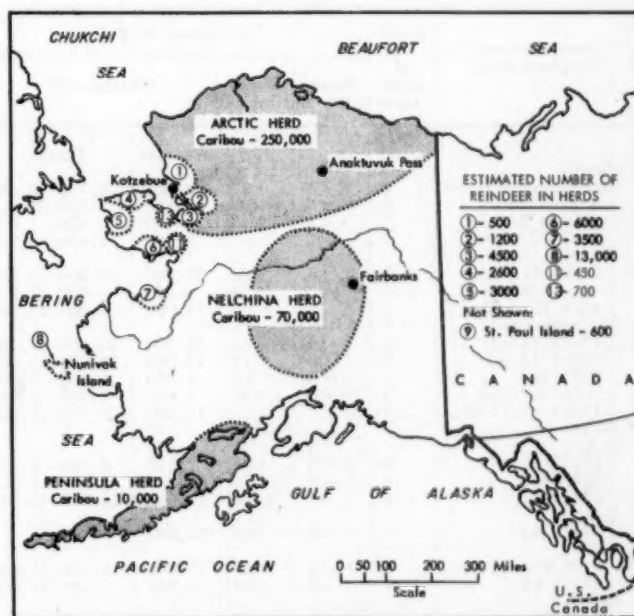

FIGURE 1.—NUMBERS OF CARIBOU AND REINDEER IN HERDS SAMPLED, 1964

Samples of muscle, rumen contents, and bone from 5 animals (two or three years old) in each herd sampled are collected in approximately April, July, September, and December of each year. The muscle samples, weighing

about two pounds each, are frozen for shipment. The bone samples consist of the hock from each animal. The rumen content samples, weighing about two pounds wet, are dried for shipment. All samples are shipped in dry ice to the Public Health Service Southwestern Radiological Health Laboratory in Las Vegas, Nevada, for analysis.

The analytical procedure includes gamma scintillation spectroscopy for cesium–137 and other gamma emitters. Strontium–89 and strontium–90 are determined by chemical separation followed by beta counting. Analysis for stable calcium is done by a flame-photometric method.

Strontium–89, strontium–90, and cesium–137 results are presented in tables 1–3 for caribou and reindeer muscle, rumen contents,

TABLE 1.—AVERAGE RADIONUCLIDE VALUES IN CARIBOU AND REINDEER MUSCLE

Specimens and sampling dates	Number of samples	pc/kg wet weight		
		Stron-tium-89	Stron-tium-90	Cesium-137
				Average	Range
Caribou					
Arctic herd 12/21/63	3	• <5	• 17	4,860	3,750- 5,680
4/27-5/19/64	5	• <5	• 400	13,800	5,000-21,000
8/20-8/29/64	5	• <5	• 40	700	400- 1,000
12/7-12/15/64	5			3,900	1,400- 5,300
Nelchina herd					
11/24-11/25/63	5	• 5	• 33	21,800	16,900-26,400
4/24-4/26/64	5	• 10	• 54	5,560	2,600-10,000
12/8-12/9/64	5			14,000	7,900-22,000
Peninsula herd					
12/12-12/19/63	5	• 10	• 84	44,800	33,600-57,700
4/9-4/15/64	5	• <5	• 14	14,800	12,000-18,000
7/11/64	4	• <5	• 5	1,680	1,400- 2,000
9/26-10/1/64	5	• <5	• 11	4,630	1,200- 9,250
12/14-12/17/64	5			18,000	8,700-31,000
Reindeer					
R-1					
12/27/63	4	• <5	• 31	7,190	6,730- 7,540
9/7/64	5	• <5	• 74	3,340	2,300- 4,900
12/15/64	4	• <5	• 268	23,000	13,000-30,000
R-2					
12/15/64	1	<5	578	34,000	
R-3					
9/26/64	2	• <5	• 68	19,600	13,400-25,800
12/15/64	4	• <5	• 64	14,000	5,100-32,000
R-4					
9/25/64	3	• <5	• 38	8,490	7,660-10,000
12/15/64	5	• <5	• 68	12,000	4,900-29,000
R-5					
12/15/64	5	• <5	• 66	35,000	25,000-47,000
R-6					
12/15/64	5	• <5	• 96	19,000	11,000-30,000
R-7					
12/24/64	5			30,000	14,000-37,000
R-8					
9/18/64	5	• <5	• 75	7,050	5,000- 9,200
12/24/64	5			25,000	9,800-35,000
R-9					
9/24/64	4	• <5	• 10	4,860	2,080- 7,530
11/19-11/20/64	5			13,000	4,400-16,000
R-13					
12/15/64	5	• <5	• 127	28,000	23,000-34,000

• Indicates samples composited before analysis.

TABLE 2.—AVERAGE RADIONUCLIDE VALUES IN ALASKAN CARIBOU AND REINDEER RUMEN CONTENTS

Specimens and sampling dates	Number of samples	pc/kg wet weight		
		Stron-tium-89	Stron-tium-90	Cesium-137
				Average	Range
Caribou					
Arctic herd					
12/21/63	3	•500	•4,440	4,430	3,980- 4,770
4/27-5/19/64	5	• <5	•1,680	4,440	4,000- 6,000
8/20-8/29/64	5	• 40	•1,700	1,470	970- 2,200
12/7-12/15/64	5			4,100	1,800- 6,300
Nelchina herd					
11/24-11/25/63	5	•400	•5,150	4,880	1,100- 7,430
4/24-4/26/64	5	• <5	•1,550	8,400	2,500-12,000
12/8-12/9/64	5			7,200	4,300- 9,000
Peninsula herd					
12/12-12/19/63	5	•1,550	•5,700	7,920	4,020-12,300
4/9-4/15/64	5	• <5	•1,370	1,840	1,400- 2,600
7/11/64	5	• <5	• 311	690	620- 740
9/26-10/1/64	5	• <5	• 825	5,890	1,500-13,300
12/14-12/17/64	5			4,900	2,200- 8,000
Reindeer					
R-1					
12/27/63	4	• <5	•5,600	4,650	3,760- 5,360
12/15/64	5			5,400	2,300- 7,900
R-2					
12/15/64	1			6,900	
R-3					
9/26/64	1	<5	315	10,900	
12/15/64	3	• <5	•5,810	5,500	5,200- 5,700
R-4					
9/25/64	1	<5	1,710	5,770	
12/15/64	5	• <5	•2,440	1,900	1,100- 2,700
R-8					
9/18/64	5	• 5	•3,060	3,600	2,500- 4,510
12/24/64	5			5,400	1,100-10,000
R-9					
9/24/64	3	• <5	• 720	1,210	660- 1,900
11/19-11/20/64	5			4,400	1,700- 8,500
R-11					
12/15/64	5			4,600	2,400- 7,400

• Indicates samples composited before analysis.

and bone, respectively. Figures 2 and 3 depict levels of strontium–90 and cesium–137, respectively, in muscle and rumen content of the three caribou herds sampled.

The muscle data are of prime interest since muscle, in contrast to rumen or bone, is an important constituent of the diet for many Alaskan residents. A tendency toward increased cesium–137 values in caribou muscle during and immediately following the winter diet and lower values during and immediately following the summer diet can be seen. The reindeer muscle data are too few to permit similar observations.

These data represent one aspect of the Division's surveillance activities in Alaska. An accompanying program for assessing radiation levels in the human population, consisting of bone sampling and whole body counting, is currently in progress.

TABLE 3.—AVERAGE RADIONUCLIDE VALUES IN ALASKAN CARIBOU AND REINDEER BONE

Specimens and sampling dates	Number of samples	pc/g ash		pc/kg wet	
		Strontium-89	Strontium-90	Cesium-137	
				Average	Range
Caribou					
Artic herd					
12/21/63	3	ᵃ 60	ᵃ 225	170	120– 210
4/27–5/19/64	5	ᵃ <5	ᵃ 143	ᵇ —	—
8/20–8/29/64		<5	137	—	—
Nelchina herd					
11/24–11/25/63	5	ᵃ <5	ᵃ 117	920	520– 1,940
4/24–4/25/64	5	ᵃ <5	ᵃ 143	—	—
Peninsula herd					
12/12–12/19/63	5	ᵃ <5	ᵃ 118	3,920	3,240– 4,780
4/9–4/15/64	5	ᵃ <5	ᵃ 116	—	—
7/11/64	4	ᵃ <5	ᵃ 115	—	—
9/26–10/1/64	4	ᵃ <5	ᵃ 90	—	—
Reindeer					
R–1					
12/27/63	4	ᵃ 25	ᵃ 64	830	750– 920
9/7/64	5	ᵃ <5	ᵃ 96	2,240	1,300–22,700
12/15/64	5	ᵃ <5	ᵃ 116	—	—
R–2					
12/15/64	1	<5	105	—	—
R–3					
9/26/64	2	ᵃ <5	ᵃ 184	3,670	1,880– 5,460
12/15/64	2	ᵃ 7	ᵃ 175	—	—
R–4					
9/25/64	3	ᵃ <5	ᵃ 115	2,050	1,080– 2,880
12/15/64	2	ᵃ <5	ᵃ 135	—	—
R–5					
12/15/64	5	ᵃ <5	ᵃ 185	—	—
R–6					
12/15/64	1	<5	197	—	—
R–8					
9/18/64	5			1,420	1,060– 1,790
12/24/64	5			2,000	360– 3,700
R–9					
9/24/64	4	ᵃ <5	ᵃ 64	460	340– 610
11/19–11/20/64	5	ᵃ <5	ᵃ 214	750	400– 880
R–11					
12/15/64	1	<5	214	—	—
R–13					
12/15/64	1	<5	177	—	—

ᵃ Samples composited before analysis.
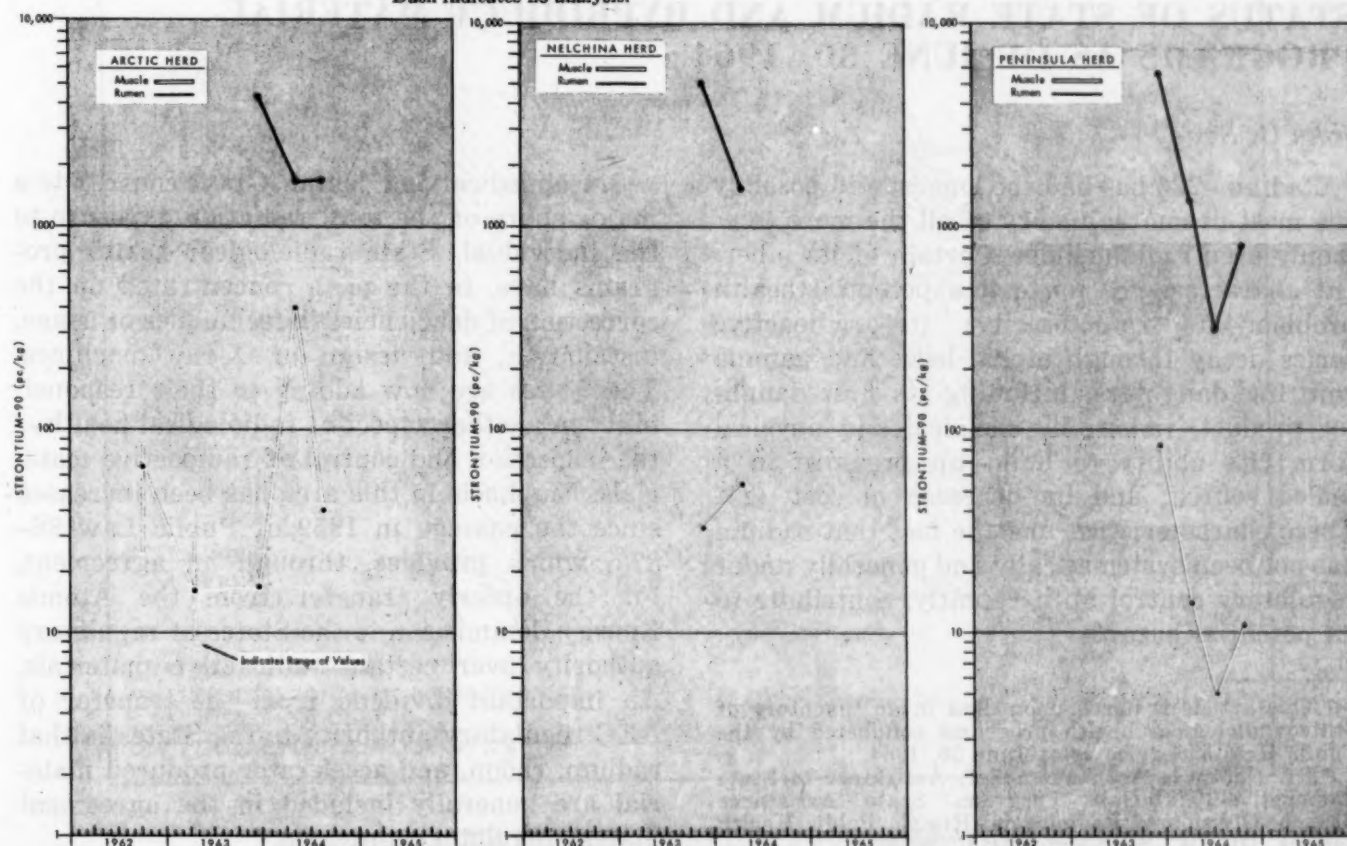ᵇ Dash indicates no analysis.

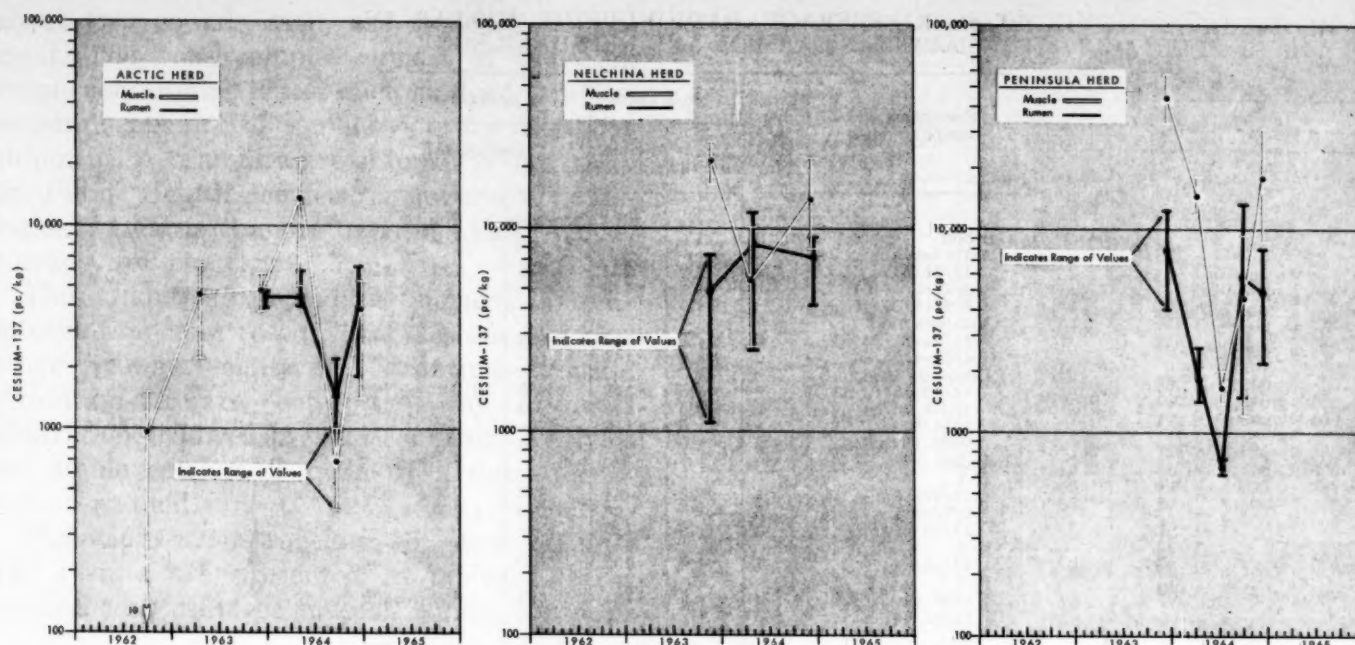FIGURE 2.—STRONTIUM-90 IN ALASKAN CARIBOU MUSCLE AND RUMEN CONTENTS

FIGURE 3.—CESIUM–137 IN ALASKAN CARIBOU MUSCLE
AND RUMEN CONTENTS

STATUS OF STATE RADIUM AND BYPRODUCT MATERIAL PROGRAMS AS OF JUNE 30, 1964[1]

John G. Bailey[2]

Radium–226 has had the longest and possibly the most dramatic history of all the more commonly used radionuclides. Certain of its inherent characteristics make it a potential health problem—its radiotoxicity; its radioactive series decay through alpha, beta, and gamma emitting daughters, including its first daughter product, radon; its chemical and physical form; its ability to build up pressure in a sealed source; and its decrease in cost (*1*). These characteristics, and the fact that radium has not been systematically and generally under regulatory control until recently, contribute to its potential hazards.

Since medical and dental X-rays contribute a major share of the total radiation exposure to the individual, State radiological health programs have, in the past, concentrated on the correction of deficiencies in techniques of usage, installation, and design of X-ray machines. The States are now adding to their responsibility in another aspect of radiological health—the inspection and control of radioactive materials. Emphasis in this area has been increased since the passage in 1959 of Public Law 86–373, which provides, through an agreement, for the orderly transfer from the Atomic Energy Commission to the States of regulatory authority over certain radioactive materials. An important dividend from the transfer of AEC regulatory authority to the States is that radium, radon, and accelerator-produced material are generally included in the agreement States' regulatory program.

Commonly used radioactive materials fall into two distinct categories: byproduct radionuclides,[3] which have had strict government licensing by either the AEC or the agreement States;[4] and those radionuclides, radium, radon, and accelerator-produced material, which until recently were under virtually no regulatory control.

As of June 30, 1964, (see table 1), six States had assumed regulatory control over byproduct materials from the AEC. An additional 28

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[3] Those radionuclides which are ". . . yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material." (Code of Federal Regulations, Title 10, Chapter 1, Part 30, Section 30.4b). For this discussion, source and special nuclear material are not included.

[4] Agreement State means ". . . any State with which the Commission has entered into an effective agreement under subsection 274.(b) of the Atomic Energy Act of 1954, as amended." (Code of Federal Regulations, Title 10, Chapter 1, Part 30, Section 30.4u).

[5] As of February 1, 1965, three additional States have assumed regulatory control over byproduct material from the AEC.

States are working toward an agreement before 1970.[5] Of approximately 8,200 organizations and individuals in the United States that possessed byproduct material licenses (licensees), 2,260 (28 percent) were licensed by the six agreement States (2). These States contain 27 percent of the Nation's population.

In addition to those States becoming responsible for regulatory control of byproduct material, an increasing number of States are developing programs for radium and other non-agreement materials. Twenty-six States, as shown in figure 1, had comprehensive programs for the control of radium. These comprehensive programs include registration or licensing of radium as well as State inspections or surveys of radium installations. An additional 12 States identified the user of radium through a registration or licensing program but had not yet developed radium inspection programs. Four other States had only limited programs of radium installation inspections. Of the 30 States with inspection programs, 15 had inspected all known radium installations.
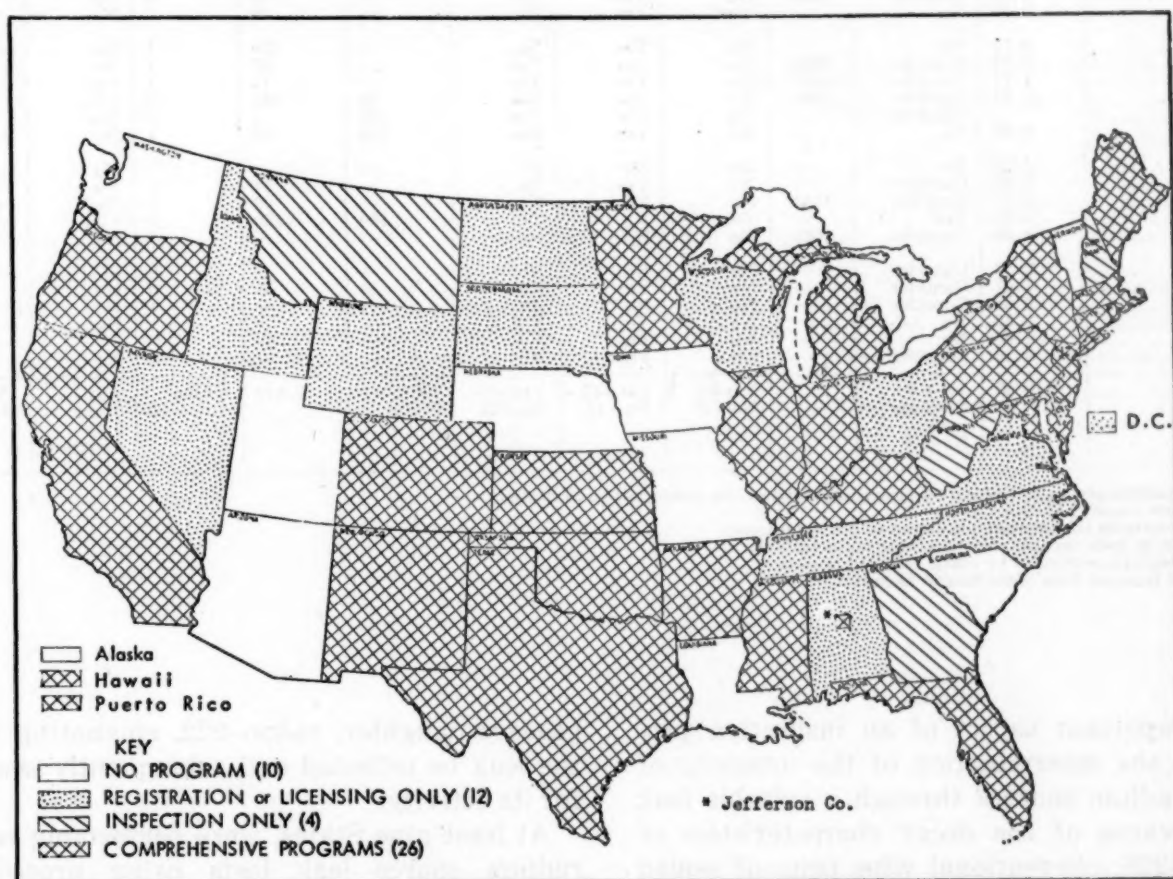

KEY
☐ NO PROGRAM (10)
▨ REGISTRATION or LICENSING ONLY (12)
▧ INSPECTION ONLY (4)
▩ COMPREHENSIVE PROGRAMS (26)

☐ Alaska
▩ Hawaii
▩ Puerto Rico

• Jefferson Co.

☐ D.C.

FIGURE 1.—STATUS OF STATE RADIUM PROGRAMS—JUNE 30, 1964

State	Population (millions) 1960 Census	AEC agreement		Radium		Radium		Radium installa-tions	Alpha survey instru-ments	States doing:	
		Status	Year planned	Licensing	Regis-tration	Inspection	Percent complete			Leak test ᵈ	Wipe test
Ala	3.27	Consider	1966	No	Yes	ᵇYes	—	—	5	ᵇYes	—
Alaska	0.23	No	ᶜ—	No	No	No	—	—	1	No	—
Ariz	1.30	Consider	—	No	No	No	—	—	0	No	—
Ark	1.79	Yes	—	Yes	No	Yes	100	33	0	No	Yes
Calif	15.72	Yes	—	Yes	No	Yes	60	310	8	ᵉNo	—
Colo	1.75	Consider	1966	No	Yes	Yes	—	—	0	No	Yes
Conn	2.54	Consider	1966	No	Yes	Yes	100	119	1	No	Yes
Del	0.45	No	—	ᶠYes	No	No	—	—	0	No	—
D. C.	0.76	Consider	1967	No	Yes	No	—	—	4	No	—
Fla	4.95	Consider	1964	No	Yes	Yes	—	—	3	No	Yes
Ga	3.94	No	—	No	No	Yes	20	50	8	Yes	—
Hawaii	0.63	Consider	—	No	Yes	Yes	100	40	1	—	—
Idaho	0.67	No	—	No	Yes	No	—	—	1	No	Yes
Ill	10.08	Consider	1966	No	Yes	Yes	100	159	3	Yes	—
Ind	4.66	Consider	1965	No	Yes	Yes	100	115	2	No	Yes
Iowa	2.76	No	—	No	No	No	—	—	2	No	—
Kans	2.18	Consider	1965	No	Yes	Yes	100	72	3	—	—
Ky	3.04	Yes	—	No	Yes	Yes	100	51	1	Yes	—
La	3.26	Consider	1966	No	No	No	—	—	1	No	—
Maine	0.97	Consider	—	No	Yes	Yes	83	18	0	No	Yes
Md	3.10	Consider	1966	No	Yes	Yes	—	—	1	No	Yes
Mass	5.15	No	—	No	Yes	Yes	—	150	3	—	—
Mich	7.82	No	—	No	Yes	Yes	—	—	3	No	Yes
Minn	3.41	No	—	No	Yes	Yes	25	64	2	No	Yes
Miss	2.18	Yes	—	Yes	No	Yes	100	57	1	No	Yes
Mo	4.31	No	—	No	No	No	—	—	0	No	—
Mont	0.67	Consider	1969	No	No	Yes	50	15	0	Yes	Yes
Nebr	1.41	Consider	1966	No	No	No	—	—	1	Yes	Yes
Nev	0.28	No	—	No	Yes	No	—	8	1	—	—
N. H.	0.61	Consider	1965	No	No	Yes	100	—	4	No	Yes
N. J.	6.07	No	—	No	Yes	Yes	100	190	2	ᵉNo	—
N. Mex	0.95	No	—	No	Yes	Yes	100	5	3	Yes	Yes
N. Y.	16.78	Yes	—	No	Yes	Yes	100	260	Many	ᵉNo	Yes
N. C.	4.56	Consider	1964	No	Yes	No	—	49	6	No	—
N. Dak	0.63	No	—	No	Yes	No	—	20	1	No	—
Ohio	9.71	No	—	No	Yes	No	—	255	1	No	—
Okla	2.33	Consider	1966	No	Yes	Yes	—	87	1	No	Yes
Ore	1.77	Consider	1965	No	Yes	Yes	—	12	1	Yes	—
Pa	11.32	Consider	1965	No	Yes	Yes	70	285	9	ᵉNo	—
P. R		Consider	—	No	Yes	Yes	100	7	1	Yes	—
R. I	0.86	No	—	No	Yes	Yes	100	60	1	No	Yes
S. C	2.38	No	—	No	No	No	—	—	1	No	—
S. Dak	0.68	Consider	—	No	Yes	No	—	14	1	No	—
Tenn	3.57	Consider	1965	No	Yes	No	—	63	1	No	—
Tex	9.60	Yes	—	Yes	No	Yes	100	120	2	ᵉNo	—
Utah	0.89	Consider	1969	No	No	No	—	—	1	No	—
Vt	0.39	Consider	—	No	No	No	—	—	0	—	—
Va	3.97	Consider	—	No	Yes	No	—	55	0	No	—
Wash	2.85	Consider	—	No	No	No	—	—	1	No	—
W. Va	1.86	No	—	No	No	Yes	—	—	1	No	—
Wis	3.95	No	—	No	Yes	No	—	67	0	—	—
Wyo	0.33	Consider	—	No	Yes	No	—	—	2	No	—
Totals	179.47	Yes=6 Consider=28 No=18		Yes=5 No=47	Yes=33 No=19	Yes=30 No=22	100%=15 States	2,810	States with=42	9 by State 5 by owners	18 by State

ᵃ Total radium programs (inspection+licensing/registration) conducted in 26 States.
ᵇ Jefferson County, Alabama, only.
ᶜ Dash indicates information not known or not determined.
ᵈ Only those tests capable of determining radon leaking.
ᵉ Leak test not performed by State, required of owner.
ᶠ Permit required from State Health Department.

An important aspect of an inspection program is the determination of the integrity of sealed radium sources through a suitable leak test. Because of the decay characteristics of radium–226, conventional wipe tests of sealed sources of radium are of limited value. A sealed radium source leak test requires that the gaseous daughter, radon–222, emanating from the leak be collected and subsequently counted for its activity.

At least nine States, were performing sealed radium source leak tests using procedures which might identify defective sources. An additional five States require the radium source

owner to perform leak tests or have them performed by commercial firms. At least 18 States perform wipe tests of either the radium source or of the storage area to determine removable contamination. Forty-two States were equipped with at least one survey meter suitable for determining the presence of alpha contamination.

From data supplied by 30 States, it is calculated that there are 20.9 radium installations per million population. Extrapolation of this figure gives a total of about 3,800 installations or individuals using radium in the United States.[6] This is a group equivalent in number to about 46 percent of the byproduct material licensees. As a check on the validity of this population extrapolated figure, the average ratio of radium installations to byproduct licensees was calculated to be 0.43 for those

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[6] Earlier estimates (1) of 4,500 installations were based on more limited information collected in 1962.

States supplying data. Using this ratio and the number of byproduct licensees, it is calculated that about 3,500 radium installations exist in the United States. The actual number of radium installations is probably greater than 3,800 because these estimates were extrapolated from only the known installations in those States with data. It should be noted that the radium installations and byproduct licensees are not mutually exclusive. In many of the facilities, the radium user will also process byproduct material.

The increase in State radioactive material programs from 16 States requiring licensing or registration of radium in fiscal year 1963 to 38 States in fiscal year 1964 is an encouraging step toward a nationwide program for radium control.

REFERENCES
(1) Villforth, John C. Problems in radium control. Public Health Rep. 79:337–341, April 1964.
(2) Data obtained from "Location and type of licensees", USAEC, June 30, 1964 (mimeo).

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

Atomic Energy Commission contractors who handle or produce radioactive materials are required to report periodically to the Commission on the environmental levels of radioactivity in the vicinity of major installations. These reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Selected summaries of the environmental radioactivity reports for 23 AEC installations are published regularly in *Radiological Health Data*. Summaries appearing in this issue cover the monitoring programs during the first half of 1964 at the following installations: Lawrence Radiation Laboratory and Mound Laboratory.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set forth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are essentially those published in the Federal Register (1).

1. Lawrence Radiation Laboratory[1]
January—June 1964

University of California
Berkeley, California

Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the University of California campus (see figure 1). Technical facilities include a 6.3 Bev proton accelerator (Bevatron), a 700 Mev cyclotron, a linear accelerator of 10 Mev per nucleon, 88-inch cyclotron, and various chemistry and physics laboratories.

The environmental sampling program includes monitoring of the atmosphere, water, and rain or dry deposition. Three types of atmospheric samples are taken: stack samples, local area samples, and perimeter samples. Data for these are shown in table 1.

[1] Data from "Environmental Sampling," January through June 1964; methodology summarized from earlier Environmental Sampling reports, Health Chemistry, LRL, Berkeley, California.

TABLE 1.—ATMOSPHERIC MONITORING, BERKELEY SITE, JANUARY–JUNE 1964

Sampling locations	Number of samples	Alpha, pc/m³	Beta, pc/m³
Stacks	4,000	0.008	1.37
Local area	248	0	2.00
Perimeter	103	0.001	2.24

Approximately 110 "stacks" with potential for releasing radioactive contaminants are sampled continuously. One-inch diameter filters are used at a flow rate of one liter per minute. The filters are changed weekly and counted for beta activity by an end-window Geiger-Mueller tube and for alpha activity by a thin-window proportional counter. Limits of detection for an individual stack sample were 0.10 pc/m³ alpha and 2.3 pc/m³ beta.

Local area and perimeter air samples are taken at locations on the Laboratory site and at the property line, respectively. The samples are taken on 4 x 9-inch HV–70 filter paper at 4 cfm. The filters are changed weekly, counted for alpha activity by a thin-window proportional counter, and for beta activity by a 30

mg/cm²–window Geiger-Mueller tube. A 40-percent loss in the alpha count is assumed for self adsorption. Limits of detection were 0.15 pc/m³ beta and 0.005 pc/m³ alpha.

Rain or deposition samples are collected monthly in 18-inch diameter cylindrical vessels lined with polyethylene bags at local area and perimeter sites. Deposition data are given in table 2. Rain samples are poured out and evaporated in beakers. If the bag is dry, it is rinsed out with dilute nitric acid; this solution is then evaporated. Final evaporation is conducted in 2-inch diameter stainless steel planchets, which are then flamed and coated with a thin film of lacquer. These planchets are counted for alpha activity in an internal flow proportional counter and for beta activity with a thin-window low-background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Detection limits vary, depending on the size of the sample and length of time counted.

TABLE 2.—TOTAL DEPOSITION,
BERKELEY SITE, JANUARY–JUNE 1964

Location	Number of samples	Alpha, nc/m²	Beta, nc/m²
Local area	52	0.05	36
Perimeter	23	0.05	31

Water samples are taken from laboratory acid waste systems, onsite streams, and offsite streams. The laboratory waste is sampled at three buildings designated by numbers 70, 71, and 74. At building 70 a continuous sample is collected from the acid waste system for weekly analyses. Samples of approximately two liters each are acidified, evaporated, and counted in the same manner as rain samples. Detection limits were ≤10 pc/liter alpha and beta.

Waste from laboratory areas in building 71 is retained in 350-gallon holding tanks until analyzed. A one-quart sample is taken from each tank and is handled and counted in the same manner as samples taken at building 70.

Surface water is sampled weekly from Strawberry and Blackberry Creeks, which comprise the Laboratory's storm drainage. Two other nearby "offsite" creeks are also sampled weekly. One-quart samples are taken in each case and handled in the same way as rain samples. The sampling stations are shown in figure 1. Results for water samples are shown in table 3.
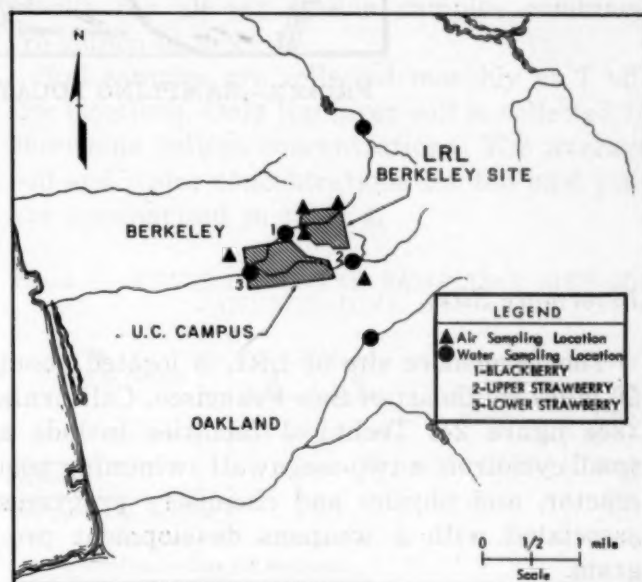

FIGURE 1.—ENVIRONMENTAL SAMPLING LOCATIONS AT THE BERKELEY SITE

TABLE 3.—WATER MONITORING, BERKELY SITE, JANUARY–JUNE 1964

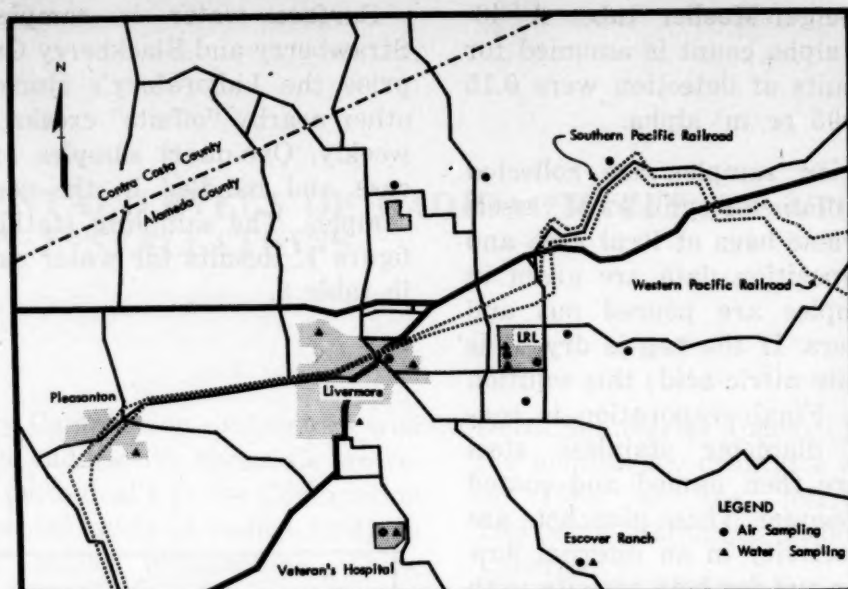| Type of sample	Number of samples	Average concentrations	
		Alpha, pc/liter	Beta, pc/liter
Hearst sewer	59	3.4	45
Sewer, bldg 74	86	<0.43	33
Tap water	25	0.07	8.4
Onsite streams	77	0.49	2.7
Offsite streams	52	0.82	4.1

FIGURE 2.—SAMPLING LOCATIONS AT THE LIVERMORE SITE

Livermore Site

The Livermore site of LRL is located about 50 miles southeast of San Francisco, California (see figure 2). Technical facilities include a small cyclotron, a two-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, and sewage plant products. Air samples are collected to ascertain that control efforts are restricting the release of radioactivity from the Laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 11 sites within 5 miles of the Laboratory. Samples are collected at a rate of 4 cfm on 4 x 9-inch HV70 filter papers which are changed every 7 days of operation. A minimum decay period of 96 hours is observed before the papers are counted to eliminate the effect of natural radon and thoron daughters. The alpha activity remaining is measured with a counter equipped with a zinc sulfide scintillation detector with a counting efficiency of about 27 percent for 5.1 Mev. The beta activity is measured with a Geiger-Mueller tube with a counting efficiency of about 12 percent for the 0.54 Mev and 2.27 Mev betas of strontium–90 in equilibrium with yttrium–90. The standards of comparison used are 0.04 pc/m³ for alpha and 1.0 pc/m³ for beta, as recommended in NBS Handbook No. 69. The limit of sensitivity is 0.00073 pc/m³ for alpha and 0.0059 pc/m³ for beta. Average activity for the eleven air sampling stations which collected 289 samples was 0.0037± 0.0022 pc/m³ alpha and 0.95±0.05 pc/m³ beta.

Domestic water samples are collected monthly from two onsite wells and six nearby areas. The average radionuclide concentration in all of the domestic water samples was below the limit of sensitivity for alpha (8.9 pc/liter)

and for beta (41 pc/liter). The standards of comparison used are 10 pc/liter for alpha and 100 pc/liter for beta, as recommended in the NBS Handbook 69. The gas proportional counter used in these measurements has a counting efficiency of 34 percent for alpha and 40 percent for beta emitters.

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore Site. The alpha activity was below the limit of sensitivity (5.0 pc/g) for all but one sample, which exhibited 5.8 pc/g. The beta activity fluctuated from the limit of sensitivity (23.0 pc/g) to 51.0 pc/g. Sewage samples are collected every Monday, Wednesday, and Friday at the sewer line leaving the southwest project boundary where it connects with the Livermore domestic sewer line. Grab samples are collected monthly at the Livermore Sewage Disposal Plant to assure that liquid effluent from the laboratory is not creating abnormal radioactivity concentrations in the oxidation ponds and dried sludge. The sludge is used as an agricultural soil conditioner. The oxidation ponds overflow into a natural waterway.

Site 300

Site 300 is located in a very sparsely populated ranching area about 17 miles southeast of the Lawrence Radiation Laboratory at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal concentrations in the vicinity. Lack of power facilities necessitated installation of most of the air samplers within the boundaries of the site. Water samples were taken from onsite wells because they are the only readily accessible source of underground water. During winter, samples are collected from streams only when there is a water flow. All air and water samples are processed at the Laboratory in Livermore.

Air sampling is conducted on a continuous basis at seven stations, but filter papers are changed on an irregular schedule. The standards of comparison for alpha are 1 pc/m³ for the onsite stations and 0.1 pc/m³ for offsite stations located at Tracy, eight miles northeast of Site 300. The standards for beta are 100 pc/m³ onsite and 10 pc/m³ offsite. Average results for all air station samples combined are shown in table 4.

Soil samples are collected monthly at 7 offsite locations. Only top layer soil is collected to determine fallout concentrations. The average soil and water concentrations for the past year are summarized in table 4.

TABLE 4.—ENVIRONMENTAL SAMPLING, SITE 300, JANUARY–JUNE 1964

Type of sample	Number of stations	Number of samples	Average concentrations	
			Alpha	Beta
Air (pc/m³)	7	356	0.0027 ±0.0013	7.7 ±0.6
Soil (pc/g)	7	ª —	5	24
Onsite wells (pc/liter)	6	—	ᵇ ND	ND
Offsite streams (pc/liter)	3	—	ND	ND

ª Dash indicates data not available.
ᵇ ND indicates activity not detectable.

Recent coverage in *Radiological Health Data:*

2. Mound Laboratory,[2]
January—June 1964

Monsanto Research Corporation

Of the radionuclides in use at Mound Laboratory at Miamisburg, Ohio, only polonium–210, plutonium–239, and hydrogen–3 (tritium) are potential environmental contaminants. No measurable amounts of penetrating radiation such as gamma or hard beta have been contributed to the environment by the Laboratory during the period covered by this report.

The environmental monitoring program, conducted by the Monsanto Research Corporation, is planned and coordinated with regard to all of the various projects performed in the Laboratory. Water and air monitoring methods and results are discussed below.

Air monitoring

A continuous air monitor for measurement of tritium and particulate air sampling equipment for measurement of alpha activity are mounted on a one-ton panel truck for use in the routine monitoring of the environmental air at 104 locations selected within a radius of 20 miles. The choice of sites on a given day depends on the wind direction at the time of collection.

During the six-month period ending June 1964, 246 samples were taken for determination of tritium in air. In all cases tritium was nondetectable.

Monitoring for possible polonium–210 and plutonium–239 released to the environment is accomplished by determination of long-lived gross alpha activity on filter paper samples. Counting is done in a low-background proportional counter. Sufficient delay time is allowed after collection to minimize interference from the daughter products of radon and thoron. The measured concentrations of alpha activity in air are summarized in table 5.

[2] Summarized from Environmental Monitoring Semi-Annual Report, January–June 1964 (MLM–1210) July 24, 1964.

TABLE 5.—LONG-LIVED ALPHA CONCENTRATIONS IN AIR IN THE MOUND LABORATORY ENVIRONMENT

Direction from laboratory relative to wind	First half 1964	
	Number of samples	Alpha, pc/m³
Upwind	243	0.0024
Downwind	40	0.0025

No specific determinations of polonium–210 or plutonium–239 were made, since the alpha activity remained substantially below the environmental MPC's for these nuclides.

It may be observed that there is no significant difference between upwind and downwind average alpha activity for the first half 1964. The gross alpha air concentration averaged over the 6-month period was 3.8 percent of the environmental MPC for plutonium.

Water monitoring

Liquid radioactive waste materials from polonium operations at the Laboratory are processed in a special waste disposal plant designed to reduce radioactivity to a concentration level at which it may be discharged to the Great Miami River (station 2, figure 3). Liquid waste from plutonium work is small in volume, is handled separately as a packaged waste, and is not discharged to the river. Helium–3, which is purified at the Mound Laboratory, contains small quantities of tritium. Liquid wastes from this work, also small in volume, are treated separately (diluted with water when necessary) to assure that the radioactivity content is below the maximum permissible concentration before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and five locations along the Great Miami River as shown in figure 3. The drainage ditch carries away all storm sewer water and liquid tritium wastes from the plant site. Sampling location number 2 is located at the point of discharge of the laboratory effluent to the Great Miami River, and number 6 is five miles downstream from the effluent outlet.

All of the river samples are analyzed for polonium–210. The drainage ditch samples and some of the river samples are analyzed for
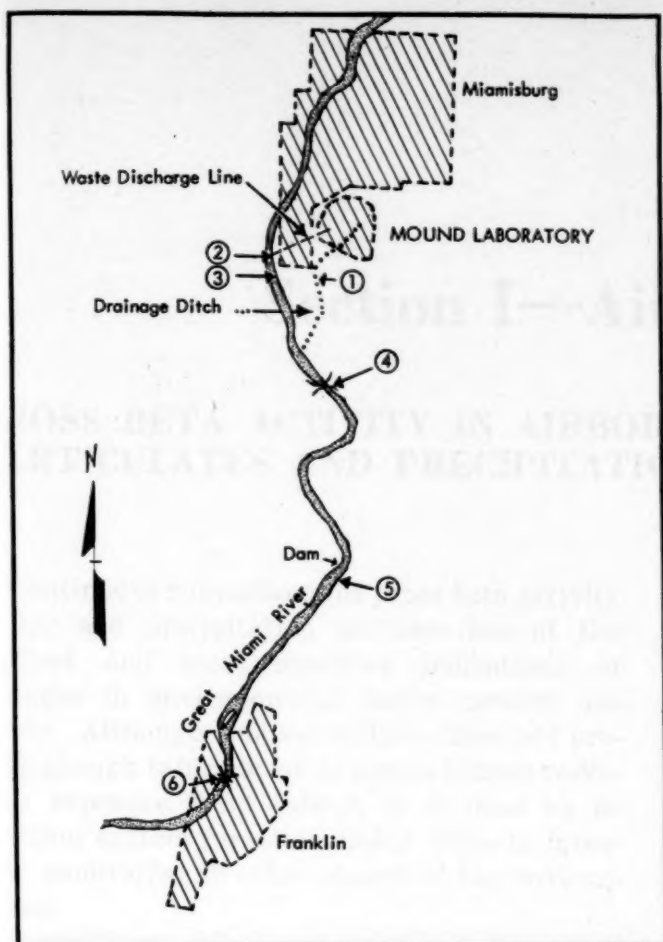
FIGURE 3.—WATER SAMPLING LOCATIONS IN GREAT MIAMI RIVER, MOUND LABORATORY

tritium. Average concentrations of tritium and polonium–210 are given in table 6. The highest polonium–210 concentration during the 6-month period was 19 pc/liter in a sample taken from station 4 collected during the first half of 1964; the average was 0.24 percent of the MPC for polonium–210. The highest tritium value found in a sample was 2 million pc/liter; the average was 2.6 percent of the MPC for the general population.

TABLE 6.—OFFSITE WATER MONITORING FOR POLONIUM-210 AND TRITIUM FROM MOUND LABORATORY

Nuclide and station number (see figure 3)	First half 1964	
	Number of samples	Average concentration, pc/liter
Polonium-210		
2 (effluent)	16	2.7
3	15	0.9
4	16	2.3
5	16	0.9
6	15	1.8
Hydrogen-3 (tritium)		
1 (drainage ditch)	17	300,000
2 (effluent)	15	0.0
4	15	70,000

REFERENCE

(1) U.S. ATOMIC ENERGY COMMISSION. Rules and regulations, standards for protection against radiation, Title 10, Part 20, Appendix B, Table 2. U.S. Government Printing Office, Washington, D.C. 20402.

Recent coverage in *RHD:*

Period	Issue
January–June 1962	*March 1963*
July 1962–June 1963	*April 1964*
July–December 1963	*November 1964*

REPORTED NUCLEAR DETONATIONS, APRIL 1965

During April 1965 three underground nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission. The first test, conducted on April 5, was of low-intermediate yield (20-200 kilotons); tests conducted on the fourteenth and twenty-first were of low yield (less than 20 kilotons).

The test of April 14 was a nuclear excavation experiment of the Commission's "Plowshare Program" for developing peaceful uses for nu-

clear explosives. The yield of the nuclear explosive was about 4 kilotons. As announced by the Commission, "Most of the radioactivity from the experiment remained underground. Some radioactivity was released. This was only a small fraction of the radioactivity which was produced, and most of it was deposited in the vicinity of the experiment. The very small amount of radioactivity released off-site does not constitute a health hazard."